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The Mammals and Birds of Camiguin Island, Philippines, a Distinctive Center of Biodiversity

Lawrence R. Heaney, Editor

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Frontispiece

Two species of mammals and one species of bird live only on Camiguin Island: *Apomys* sp. (described herein; center left), *Bullimus gamay* (described by Rickart et al. in 2002; lower right), and *Loriculus* sp. (described herein; upper center). The distinctive volcanic peaks of Camiguin form the background.

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Contents

List of Figures (abbreviated titles)

List of Tables (abbreviated titles)

Preface

The Philippine Islands have been recognized for over a century as having a fauna that is characterized by large numbers of endemic and highly distinctive species. For most of this period, the mammals and birds were thought to be well known, based on studies conducted in the period 1880–1950. However, the description of new species during the 1980s implied that diversity was higher than had been believed and suggested that there might be additional localized centers of endemism yet to be found. In addition, it was during the 1980s that the extent of rain-forest habitat destruction became apparent and increased the need for extensive and detailed documentation of biological diversity to guide development and conservation for the benefit of both wildlife and the human population of the Philippines.

With this in mind, the authors of this volume and their colleagues began investigations of places likely to be of special interest and initiated a series of publications in *Fieldiana: Zoology* to document the findings. The field studies have been conducted in a standardized fashion to allow direct and meaningful comparison between study areas so that geographic patterns of species richness between islands and mountain ranges and along elevational gradients could be documented. However, older museum collections, which often were unreported in the published literature, have also been utilized, increasing the rate of our progress in understanding the remarkable mammal and bird faunas of the Philippines. The first publications in *Fieldiana* concerned the mammals of Leyte and nearby islands north of Mindanao, the birds and mammals of Mt. Isarog National Park in southern Luzon, and the birds of Sibuyan Island. Plans are in place for similar publications on the mammals and birds of the Kitanglad Range of northern Mindanao and the mammals of Sibuyan Island, and others are likely to follow.

This volume contains the results of our studies of Camiguin Island, a small island that lies just north of central Mindanao. It is easily overlooked on a map of the Philippines, yet, as shown here, the island supports an endemic species of small parrot and two endemic species of small mammals, all discovered in the course of our studies. Announcements in the Philippine press of the discovery of the mammals in 1994 and 1995 played an important role in encouraging the declaration of the remaining rain forest on Camiguin as a national park, a movement that is continuing to gain support. It is our hope that this publication will help guide the planning for this protected area and its management when it has been formally initiated. The data contained here constitute a baseline from which changes may be measured in the future and also make clear how much additional study is needed. Although Camiguin is a small island, it represents an ideal natural laboratory in which to investigate many aspects of the evolution and conservation of biological diversity.

The assistance of many individuals is acknowledged in each of the chapters that follow, but we must give special recognition here to the Philippine Department of Environment and Natural Resources for providing both permits and encouragement; we especially thank Dr. Angel C. Alcala, Dr. Corazon Catibog-Sinha, Mr. Carlo C. Custodio, Atty. Wilfredo Pollisco, and Dr. Mundita Lim for their steadfast support. This project has benefited greatly from the financial support provided by the John D. and Catherine T. MacArthur Foundation, from the Ellen Thorne Smith and Marshall Field Funds of the Field Museum, and especially the Barbara Brown Fund for Mammal Research of the Field Museum.

L. R. Heaney
November 2005
Chicago, Illinois

1

Mammal and Land Bird Studies on Camiguin Island, Philippines: Background and Conservation Priorities

Lawrence R. Heaney[1] and Blas R. Tabaranza, Jr.[2]

Abstract

Camiguin Island, with an area of ca. 265 km^2 and maximum elevation of ca. 1620 m, lies about 10 km north of Mindanao but is isolated from Mindanao by a deep (385 m) channel. It originated from volcanic activity as a dryland island not earlier than 1 million years ago, but most growth of the island has occurred within the past 340,000 years. Current landforms are dominated by large, scenic volcanic peaks, several of which are active. Lowland rain forest originally occurred up to about 1100 m elevation, with montane rain forest from 1100 m to about 1350 m and mossy forest from 1350 m to the peaks. By the mid-1990s, deforestation had removed most natural vegetation below about 600 m, with degree of disturbance to forest decreasing with elevation and ending at about 1250 m. The climate is tropical, with rainfall of 2–3 m per year in the lowlands and probably about 7.5 m near the peaks. Mammal and/or bird specimens are available from 18 sites from the 1960s and 1990s; these sites are here located and described to the extent possible. Given the presence of two endemic species of mammals (one described in this volume), one endemic bird (described in this volume), and previously described endemic plants and a frog, Camiguin is one of the smallest but most distinctive centers of biodiversity in the Philippines and should be a priority site for conservation. The remaining forest on Camiguin is essential habitat for these unique species, but it is also essential for watershed protection and control of floods and landslides, and it contributes significantly to the tourism trade that provides substantial income on the island. Deforestation for logging and agriculture and overhunting are current threats. A protected area on the island should include the full range of original habitat diversity, which would encompass both the existing high-quality forest at upper elevations and also significant tracts of disturbed but natural lowland forest, especially along rivers and streams, that should be allowed to regenerate in the future.

Introduction

The mammal and bird faunas of the Philippine Islands are remarkable for the high total diversity of the fauna and especially for the remarkably large number of endemic species (e.g., Dickinson et al., 1991; Mittermeier et al., 1997, 1999; Heaney & Regalado, 1998; Heaney et al., 1998; Stattersfield et al., 1998). For example, at least 512 of the 898 species of breeding terrestrial vertebrates (57%) are endemic to the Philippines, an unusually high value (Heaney & Regalado, 1998). Most of the species endemic to the country occur on the large islands of Luzon, Mindanao, Mindoro, Negros, and Palawan (e.g., Hauge et al., 1986; Heaney, 1986; Heaney et al., 1998; Collar et al., 1999; Peterson et al., 2000),

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FIG. 1. Photograph of Camiguin Island from south-southeast, taken on 27 March 1995. All the volcanic peaks visible on the island are less than 350,000 years old: Mt. Ginsiliban, in the left foreground, is the oldest (see text).

but significant numbers of endemic mammals are restricted to some of the smaller islands as well (e.g., Heaney, 1986; Goodman & Ingle, 1993; Heaney & Tabaranza, 1997; Musser et al., 1998; Heaney & Mallari, 2002; Rickart et al., 2002). Evidence has suggested that those small islands with endemic species are nearly always islands surrounded by deep water (more than 125 m), so that they were not connected to adjacent larger islands during periods of low sea level during the "ice ages" of the middle and late Pleistocene, when sea level dropped to no more than 120 m below present level (Heaney, 1986, 1991a,b; Heaney & Regalado, 1998; Hanebuth et al., 2000; Siddall et al., 2003). Clearly, if we are to understand the overall patterns of the evolution and ecology of diversity in the Philippines, we must understand the biodiversity patterns of these smaller centers of endemism as well as the larger ones.

One of the smaller Philippine islands surrounded by deep water and still retaining moderate rain-forest cover is Camiguin, located about 10 km off the north-central shore of Mindanao Island, with minimum intervening water depth of 385 m (the island of Camiguin Norte, which lies north of Luzon, is often confused with Camiguin). It is a steeply mountainous island (Fig. 1) of about 265 km^2 with several active volcanic cones that reach to a maximum elevation of about 1620 m. A series of biological surveys on Camiguin in the late 1960s (described below) that focused on birds also yielded some mammal specimens. An earlier report on the mammals (Heaney, 1984) concluded that the island had no endemic mammal species and that it was depauperate relative to its area. Subsequent studies on other islands made us suspect that those earlier mammal surveys were incomplete because so few mammal species had been obtained and because the number of nonvolant mammal voucher specimens was small (thus indicating limited sampling effort). To investigate the hypothesis that the previously measured species richness of mammals was low because of incomplete surveys, we returned to Camiguin briefly in 1992 and more extensively in 1994 and 1995 to conduct additional mammal inventories in all the major habitats along the elevational gradient, especially by trapping small mammals at higher elevations (Heaney & Tabaranza, 1997), and we obtained some new data on the birds as well. In this volume, we summarize results from both the 1960s and the 1990s surveys and present evidence that both endemic mammal and bird species are present on the island (Heaney et al., 2006; Tello et al., 2006).

There is a second reason that we conducted surveys on Camiguin in the mid-1990s. While the Philippines is increasingly being recognized as a global center for biodiversity, with unusually high levels of endemism, it has simultaneously vaulted into public view as one of the most severely deforested of the tropical countries and home to what may be the greatest concentration of endangered species of mammals and birds (Collar et al., 1994, 1999; Heaney & Regalado, 1998; Stattersfield et al., 1998; Mittermeier et al.,

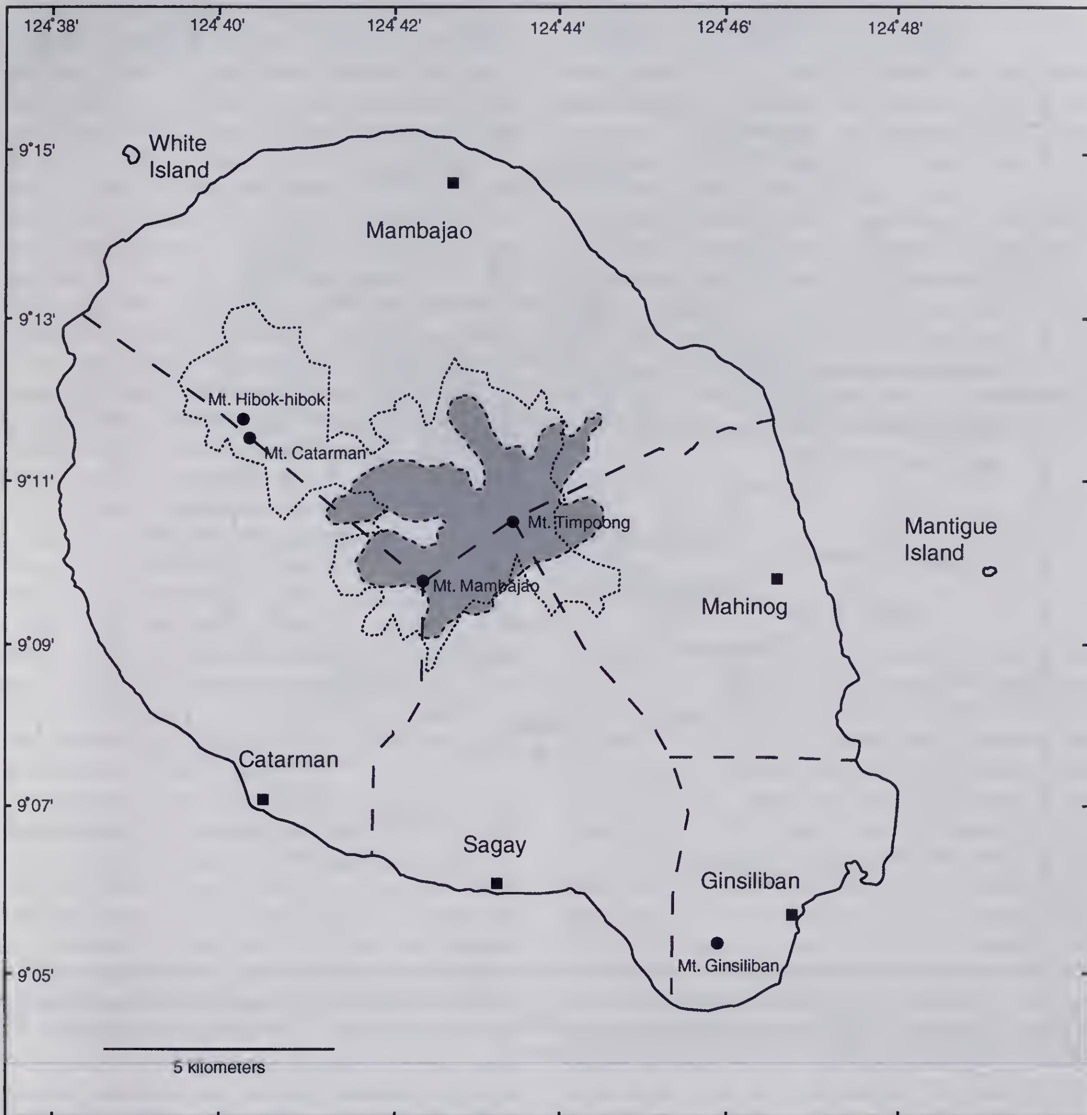

FIG. 2. Map of Camiguin Island showing the locations of mountain peaks referred to in the text, boundaries of municipalities in the mid-1990s, the approximate boundaries of the proposed Timpoong–Hibok-hibok Natural Monument (dotted line), and extent of forest cover in 1987 (gray area bounded by dashed line) from National Mapping and Resource Information Authority (1988). The names of the municipalities are adjacent to the primary population centers (= poblacion) of each municipality, shown as solid squares.

1999; Environmental Science for Social Change, 2000; Ong et al., 2002). Satellite maps of forest cover from 1986 (National Mapping and Resource Information Authority, 1988) showed a substantial area of forest cover in the center of Camiguin (Fig. 2); such forest cover is now a rarity in the Visayas (the islands of the central Philippines) and adjacent regions (Heaney & Regalado, 1998; Environmental Science for Social Change, 2000), a portion of the country where the concentration of endangered mammals and birds is especially high (Wildlife Conservation Society of the Philippines, 1997; Collar et al., 1999; Heaney & Mallari, 2002). Because deforestation has generally proceeded rapidly all over the country in recent decades, we felt a sense of urgency to obtain current information. Simultaneously, the prospect of finding species of

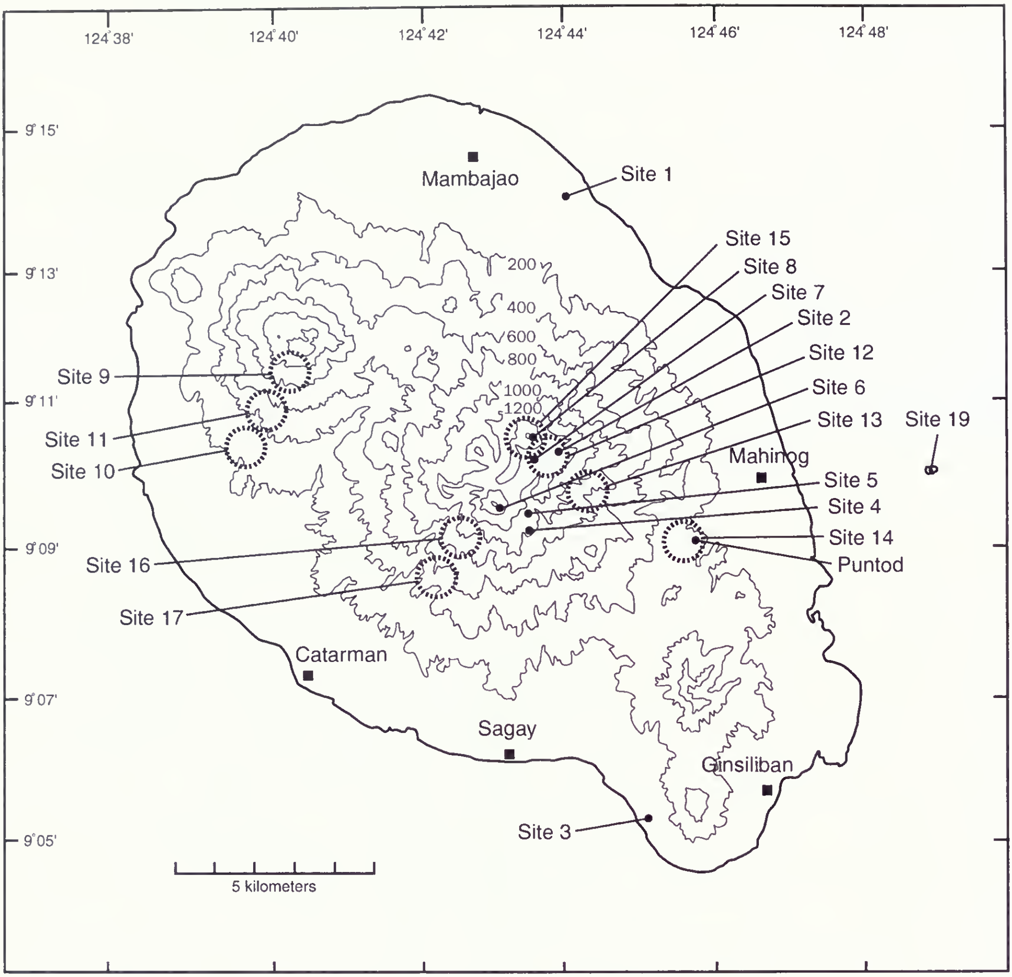

FIG. 3. Map of Camiguin Island showing 200-m elevational contours and locations of collecting sites in the 1990s (solid dots) and 1960s (dashed circles); as noted in the text, the locations of the latter are approximate. The municipal population centers are shown also (solid squares).

mammals or birds in a place where enough forest remained to support stable populations of any endemic or endangered species was quite exciting, posing the potential for positive action and the development of successful conservation programs. We therefore proceeded to Camiguin with a sense of cautious optimism and found conditions that confirmed all our best hopes but also some of our fears, as we shall describe here.

Geology, Vegetation, and Climate

Camiguin is composed almost entirely of Quaternary volcanic material from currently active volcanoes, and eruptions have occurred within historic time (Hamilton, 1979; Mitchell et al., 1986; Hall, 1998, 2002), with the most recent serious eruptions in 1871 and 1951 (Agoo, 1995). Five major and several secondary volcanic peaks (Figs. 1–3) dominate the island's landscape and serve as a tourist attraction; hikers often reach the crater lake in Mt. Hibok-hibok and visit the steam vents along its sides.

Camiguin is the northernmost, somewhat isolated portion of the Central Mindanao Arc of volcanic activity, which includes areas from Mt. Apo in the south to Mts. Kalatungan and Kitanglad in the center and Camiguin in the north (Sajona et al., 1997). Volcanic activity in this arc originated about 2.5 million years ago (Ma), though most has taken place since about

1.25 Ma. Camiguin is probably derived from a single source of magma that first produced undersea lavas in the late Pliocene or early Pleistocene (ca. 2 Ma), with dryland appearing not earlier than 1 Ma. Potassium-argon dating shows the oldest dated magmatic materials on the island to be those of the Mt. Ginsiliban and Mt. Butay volcanoes in the southeastern corner of the island (Fig. 1), which date to 0.34 Ma. The peaks and volcanic flows associated with Mt. Mambajao that form much of the center of the island are much younger, and Mt. Hibok-hibok in the northwestern portion of the island is the youngest and only currently active vent (Punongbayan & Solidum, 1985; Sajona et al., 1997; Castillo et al., 1999). We interpret this to indicate that Camiguin originated as a dryland island not earlier than 1 Ma and had high peaks and substantial area by at least 300,000 years ago, though possibly somewhat earlier (Heaney 1986, 1991a, b). The island is surrounded by deep water, with a minimum depth to Mindanao of 385 m, which far exceeds the lowest documented late or middle Pleistocene sea lowering of ca. 120 m (Siddall et al., 2003); thus, there is no evidence of a dryland connection to Mindanao at any time in the past.

Camiguin Island lies within a climate zone characterized by annual rainfall of 2–3 m or more in the lowlands, with seasonal variation that includes a moderately dry period from March to May (2.0–5.5 inches/mo; ca. 5–14 cm/mo), especially wet from October to January (10–15 inches/mo; ca. 25–38 cm/mo), and moist during the rest of the year; mean annual rainfall for a 24-year period at Mambajao was 99.4 inches (ca. 252.5 cm; Manalo, 1956). Temperature declines and rainfall increases with an increase in elevation; based on patterns elsewhere in the Philippines (Heaney & Regalado, 1998), we estimate that rainfall at 1500 m is roughly triple that at sea level (i.e., about 7.5 m/year), but no details from Camiguin are available.

The original vegetation of Camiguin was lowland tropical rain forest from near the sea to about 800 m elevation, with montane and mossy forest to the peaks, but by the mid-1990s, virtually no original vegetation remained below 300 m and little from 300 to about 800 m (Agoo, 1995). Beach and mangrove forest once occurred along the coast, but little remains. Agoo (1995, p. 4) described the upper elevations of Mt. Hibok-hibok as a submontane plant community "dominated by shrubby plants of *Radermachera, Rhododendron, Medinilla*, and *Vaccinium*. Gymnosperms are conspicuously absent. . . . The vegetation at the peak is devoid of tall trees and shrubs. It is composed mostly of turfs of grasses." Descriptions of vegetation at our sampling areas during the 1990s are below.

Agoo (1995) noted the presence of the following plants endemic to Camiguin: *Miquelia reticulata* (Icacinaceae), *Medinilla multiflora, Memecylon subcaudatum* (Melastomataceae), *Syzigium camiguense* (Myrtaceae), *Coelogyne confusa*, and *Goodyera ramosii* (Orchidaceae).

A small frog (*Oreophryne nana*) was the only endemic vertebrate known from Camiguin when we began our work (Alcala & Brown, 1998).

Methods

Prior Reports

Aside from a very small number of scattered records (e.g., Gray 1843, who reported *Paradoxurus hermaphroditus*) and a few specimens of birds from the 1930s deposited at the Museum of Comparative Zoology, the first significant surveys of birds and mammals on Camiguin were conducted by field teams from Silliman University at 10 sites in 1967, 1968, and 1969 and on the small offshore island of Mantigue in 1969. The field team in 1967 was led by D. P. Empesso and R. B. Gonzales; we know of only bats collected by this team, all of which were deposited in the Royal Ontario Museum. Labels on specimens indicate that collecting was conducted at three sites, listed below as Sites 16–18. No field catalogs or notes were kept, and no information is available on their field procedures, but we suspect that they followed roughly the same procedure as was used in subsequent years by Dioscoro S. Rabor, as follows. Field teams in 1968 and 1969, which produced all the bird specimens and many of the mammals cited here, were headed by Rabor; his teams worked at seven sites, according to the labels on specimens in the Field Museum of Natural History (FMNH) and Delaware Museum of Natural History (DMNH). B.R.T. Jr. worked on several of Rabor's teams during the 1970s and observed that Rabor followed a standardized approach to fieldwork. The field crew simultaneously occupied a base camp, where Rabor remained most of the time, and several satellite camps. The satellite teams, made up of two or

three persons, would go to areas chosen by Rabor and operate for several days to several weeks. Members in each satellite camp would set nets each day, sometimes would run a small number of large snap traps, and would hunt using shotguns over an area that could readily be covered on foot. Once each day, one member would hike to the base camp with the specimens obtained since the last such trip, then return to the satellite camp. A similar team of collectors would operate in the area of the base camp as well. At the time of collection, specimens were labeled simply, usually with the name of the site (often the name of a barangay or sitio, which could cover many square kilometers) and rough estimate of elevation based on topographic maps. Rabor would work with a team to prepare specimen labels (including measurements, date, and locality data) and to skin and stuff specimens. No field catalog or notes were usually kept; data were recorded only on the specimen skin tags (see also Rabor, 1966).

We have reconstructed the activities at Rabor's field sites by listing all the locality names that were noted and compiling the dates on which specimens were obtained. Because field teams operated simultaneously, the dates overlap. We noted the elevation, when present, for each locality name, providing us with a range of elevations for that site; many labels lack elevation, but we assume that the elevations noted apply to all specimens from a given site. We believe, however, that many of the elevations as indicated on the labels of the specimens collected during this period were overestimated and that they should be used with caution. Additional comments on elevational records can be found in specific site descriptions.

Recent Data

Field studies that focused on mammals but also obtained some data on birds were conducted during three periods in 1992, 1994, and 1995 by representatives from the FMNH and Mindanao State University–Iligan Institute of Technology. The first reconnaissance trip extended from 26 to 30 May 1992; bats were netted at a single agricultural site by a field team led by A. T. Peterson. The second period extended from 4 May 1994 to 4 June 1994; specimens were collected at one agricultural site and three forest sites by a team led by B.R.T. Jr. The third period extended from 12 to 26 March 1995; specimens were collected at two forest sites by a team led by L.R.H. and B.R.T. Jr. Our methods for sampling mammals and birds are presented in the relevant chapters.

Study Sites

Camiguin is dominated by a series of volcanic peaks, and most localities refer to those peaks. We note that the three adjacent high peaks near the center of the island (Fig. 3) are often collectively referred to as Mt. Mambajao, though we follow local people in referring to the northeasternmost of the three major peaks as Mt. Timpoong and the southwesternmost as Mt. Mambajao.

Sites from 1990s

We surveyed mammals at one site in 1992, four in 1994, and two in 1995; these are referred to in the species accounts by number, and their locations are shown in Figure 3. Additional minor sites are described in the species accounts. The dates include only those days when specimens were obtained. Distances are given from the municipal town centers, as shown in Figure 2.

Site 1—Barangay Balbagon, 1 km S, 2 km E of Mambajao, 10 m, 9°14.5′N, 124°44′E (28–29 May 1992). This site was situated in a highly disturbed lowland agricultural area. The area originally was lowland rain forest but in 1992 was a mosaic of agricultural fields, pastures, and small bits of secondary lowland forest. Several patches of shrubbery with heights of 2–4 m were present, as were several large, thick patches of erect bamboo. Six nets were set for a single night. Bats and some birds were collected.

Site 2—Barangay Balbagon, 7 km S, 2 km E of Mambajao, 1000 m, 9°10.5′N, 124°44′E (28–29 May 1992). A few specimens of birds were netted in extensive, regenerating secondary forest at this site.

Site 3—Barangay Manuyog, Sagay Municipality, 7 km S, 3 km W of Mahinog, 0–300 m, 9°5.5′N, 124°45.5′E (5–11 May 1994). Sampling was conducted in heavily disturbed lowland agricultural land, with very few scattered patches of degraded lowland forest along steep slopes beside rivers. Trapping and netting were conducted from close to the shoreline (ca. 50 m from the beach) up to 300 m along the southwestern slopes of Ginsiliban Peak, extending partially

into Ginsiliban Municipality, for a total of three net-nights and 148 trap-nights.

Site 4—Barangay Kital-is, Sagay Municipality, ½ km N, 6½ km W of Mahinog, 1000 m, 9°9.5′N, 124°43.5′E (14–24 in May 1994). This site was in disturbed transitional lowland/lower montane forest along the southwestern slopes of Mt. Mambajao at 900–1100 m elevation. The slope was moderate, and the ground was covered with abundant leaf litter. The vegetation consisted mostly of small trees with dbh of 15–25 cm and a few large trees standing 20–30 m high and with 40–60 cm dbh; some lianas (5–10-cm diameter), rattan (*Calamus* spp.), and climbing bamboo (*Schizostachyum* spp.) clung to these emergents. *Ficus* spp. were common. The most common epiphytes were orchids, moss, and ferns. Tree ferns (*Cyathea* spp.) and rattan (*Calamus* spp.) seedlings were abundant as ground cover. Scattered areas of humus were up to 30 cm thick. Our total sampling effort at this site consisted of 24 net-nights and 907 trap-nights.

Site 5—½ km N, 6½ km W of Mahinog, Sagay Municipality, 1200 m, 9°9.5′N, 124°43.5′E (26–29 May 1994). This site was situated in disturbed lower montane forest on moderate slope at 1000–1300 m elevation, in the vicinity of Lasak-lasak (Site 12). There was some evidence of small-scale illegal logging done about a year previously. Emergent trees had dbh of between 40 and 60 cm and heights up to 30 m. Lianas and canopy epiphytes (mainly ferns and mosses) were present. Rattan (*Calamus* spp.) and climbing bamboo (*Schizostachyum* spp.) were also present, with pitcher plants (*Nepenthes*) present but rare. Understory and ground cover consisted of rattan seedlings and ferns, with some sedges. Leaf litter covered about 80% of the ground, and humus was typically about 30 cm thick. Our total sampling effort consisted of 339 trap-nights; at this site, nets were concurrently maintained with those at Site 6 for a total of 14 net-nights.

Site 6—Barangay Kital-is, Sagay Municipality, on a small peak near Mt. Mambajao, 1 km N, 7½ km W of Mahinog, 1300 m, 9°10′N, 124°43′E (26–29 May 1994). This site was situated in primary mossy forest at 1200–1400 m. Hanging moss was abundant on trees, but moss cover on the ground was light and the humus layer not more than a few centimeters thick. Our total sampling effort consisted of 348 trap-nights for this site and 14 net-nights for Sites 5 and 6 combined.

Site 7—Mt. Timpoong, 2 km N, 6½ km W of Mahinog, 1275 m, 9°10.5′N, 124°43.5′E (17–25 March 1995). This site was situated in primary montane forest (Fig. 3) at 1225–1350 m elevation, in the vicinity of Lasak-lasak. The average slope was ca. 35° and was often steep. The forest had a fairly low and relatively open canopy; the height of emergent trees was usually 20–25 m, but a few reached 30 m; dbh was 12–30 cm, and none had buttresses. The canopy was broken by many treefalls, and canopy leaf sizes were small, 3–6 cm, often with serrated edges. Lower strata leaf sizes were 4–20 cm and usually 6–10 cm. Epiphytes were abundant, including ferns, orchids, and mosses. Arborescent pandans (*Pandanus* sp.), melastome shrubs (*Melastoma* spp.), and tree ferns (*Cyathea* spp.) were common, and climbing rattan (*Calamus* spp.) and viney pandans (*Freycinetia* spp.) were abundant; *Ficus* and *Musa* were rare to absent. This area had thin to moderate leaf litter cover and thin to moderate humus (up to 15 cm deep); the soil consisted of lightly weathered volcanic rock with many stones at the surface and was generally very shallow. There were no signs of human disturbance, but many trees had fallen because of very shallow soil, probably during occasional typhoons. There were eight net-nights and 655 trap-nights.

Site 8—Mt. Timpoong, 2½ km N, 6½ km W of Mahinog, 1475 m, 9°11′N, 124°43.5′E (22–25 March 1995). Sampling at this site was conducted in mossy forest. The site was on a steep slope, averaging 50°, and ranged from 30–70°, including steep gullies. The height of the canopy was usually 8–10 m but varied from 2 to 3 m in exposed spots to a maximum of ca. 18 m in low, protected places; trees were generally gnarled, with dbh of 12–20 cm (rarely 25 cm). Canopy leaves were small, with serrated edges, typically 1–8 cm, but most were 4–5 cm. Oaks, laurels, tree ferns, and arborescent *Pandanus* were common. Lower-strata leaves were small, usually 4–8 cm. *Ficus* and *Musa* were rare to absent. Epiphytes were abundant, including mosses, ferns, orchids, and saplings, and pitcher plants (*Nepenthes* spp.) were common. Canopy vines (*Freycinetia* spp. and *Calamus* spp.) were abundant. Ground plants included ferns, saplings, and abundant pandans (*Freycinetia*). The ground was covered by abundant and thick leaf litter over deep humus (over a half meter thick, with many tunnels and vacuities). Moss covered nearly all tree trunks, branches, and fallen logs and hung from branches in sheets and often

covered the ground. No human disturbance was seen, but there was evidence of some large landslides and many tree falls. No netting was performed at this site; there were 386 trap-nights.

Sites from the 1960s

As noted above (see Methods), field teams from Silliman University conducted surveys on Camiguin at 10 sites in 1967–1969 plus an additional site on the small, adjacent Mantigue Island. As noted above (Methods), we have estimated the location of these sites; our estimates are shown in brackets. The vegetation types and condition at these sites were not noted by the collectors. We surmise, on the basis of specimens collected here and the condition of the remaining vegetation on Camiguin in the 1990s, that when the collecting was done, the vegetation below 800 m ranged from secondary lowland forest to heavily populated agricultural areas. By the time of our surveys in the 1990s, the lowland forest was almost totally cleared and replaced with coconuts, and hardly any area below 800 m supported remnant forest except along steep slopes. During the 1960s, from ca. 1000 m up to the peak, the sites would have been covered with primary montane and mossy forest, as they were in the 1990s.

SITE 9—Mt. Catarman, Catarman Municipality, 2000–4950 ft (ca. 600–1500 m) [approx. 5.5 km S, 4.5 km W Mambajao, 9°12′N, 124°40.5′E] (10–29 June 1968). This was the highest site surveyed in 1968; both birds and mammals were collected. Mammals were collected at 2500–4500 ft (ca. 750–1400 m). The majority of the birds specimens were taken on 12–21 June, but a few others were collected on 10, 25, and 29 June. Bird specimens were taken from 2000 to 4950 ft (ca. 600–1500 m). This would suggest that the team sent to this camp concentrated their efforts from the middle to the upper slopes, including the peak of Mt. Catarman, but several were taken at 1000 ft (ca. 300 m) on 14 and 16 June 1968. However, we also know that collecting at this site was done simultaneously with Site 11, and specimens from both sites were then taken down to the base camp at Site 10 for processing by D. S. Rabor. We suspect that in the process, there was some mixing up of elevational data for some specimens (see also Site 11). Furthermore, the highest peak of the Mt. Catarman does not exceed 1400 m, so all the specimens cited by the team to have been collected on this mountain above this elevation were probably obtained close to the peak.

SITE 10—Gidag-on, Catarman Municipality, 500–1500 ft (ca. 150–450 m) [approx. 9°10.5′N, 124°39.5′E] (13–28 June 1968). This was the lowest campsite during the 1968 field season; birds and mammals were collected. Birds were collected mostly from 23 to 28 June 1968, with a few taken on earlier dates (13, 16–17, and 19 June). Some birds collected on 13 June were noted to have been collected at 2000 ft (ca. 600 m), possibly the highest point reached from this site. Because it was the lowest campsite in 1968, it is the most likely location of the base camp that year. We are unable to locate this site, but some collecting dates at this site overlapped with Sites 9 and 11; we suspect that it was on the lower slopes of Mt. Catarman. No information on the vegetation when the specimens were collected at this site is available, but we surmise that it would have been partly secondary lowland forest and partly agricultural.

SITE 11—Kasangsangan, Catarman Municipality, 1000–2500 ft (300–800 m) [approx. 9°11′N, 124°40′E] (11–22 June 1968). This was the middle campsite in 1968. We are unable to locate this site, but because collecting dates overlapped with Site 9, we suspect that it was mainly on the lower to middle slopes of Mt. Catarman. Several specimens were collected up to 4950 ft (ca. 1500 m), which might indicate that the team assigned to this site ventured all the way to the peak of Mt. Catarman, but we suspect mixing of localities, as noted above. No information on the vegetation when the specimens were collected is available, but we surmise that, similar to Site 9, it would have been partly secondary lowland forest and partly agricultural.

SITE 12—Mt. Timpoong, Lasak-lasak, Mahinog Municipality, 4400–5700 ft (ca. 1350–1700 m) [approx. 9°11′N, 124°43.5′E] (19–28 June 1969). We traveled through this site in 1995; it is located near the headwaters of the Sagay River, from 1200 m to roughly the peak. This was the highest site surveyed in 1969; birds and mammals were collected. Collecting activities were conducted from 19 to 28 June. The majority of the bird specimens were taken at 4800–5700 ft (ca. 1500–1700 m), indicating that the team concentrated their collecting in the high-elevation habitats on Mt. Timpoong. Several specimens were taken slightly farther down, at 4400 ft (ca. 1350 m). On 23 June 1969, some

specimens attributed to this site were noted as taken at 800 m. As with the previous year at Sites 9–11, collecting at this site was done simultaneously with Site 13, and specimens were taken down to the base camp at Site 14 for processing. We suspect that some mixing up of elevational data for some specimens from among the three sites occurred. While the vegetation at this site was not indicated when the 1960s collecting was undertaken, it would have been primary mossy forest, based on the condition of the habitat that we saw on Mt. Timpoong in the 1990s.

Site 13—Mt. Timpoong, Matugnao, Mahinog Municipality, 3150 ft (ca. 950 m) [approx. 9°10′N, 124°44.5′E] (12–26 June 1969). This was the middle campsite established in 1969; birds and mammals were collected. The majority of the bird specimens bear the elevation 3150 ft (ca. 950 m), with a few at 3250 ft (ca. 1000 m), around the midslopes of Mt. Timpoong. A few specimens, however, were noted as taken at 800 ft (ca. 250 m) on 16 June and at 4800 ft (ca. 1500 m) on 20 June. Collecting at this site was done simultaneously with Sites 12 and 14, and we suspect that some mixing of elevational data occurred.

Site 14—Puntod, Mahinog Municipality, 800 ft (ca. 250 m) [approx. 2 km N, 2 km W Mahinog; 9°9.5′N, 124°46′E] (24–29 June 1969). This was the lowest campsite established in 1969; birds and mammals were collected. Bird collecting took place on 24–29 June. Elevations were all given as 800 ft (ca. 250 m), with a single bird specimen bearing an elevation of 700 ft (ca. 200 m). Puntod is a village located on the lower slopes of Mt. Timpoong, about 2 km west of the town center of Mahinog (Fig. 3). This probably was the base camp during the 1969 field season. The vegetation in the 1960s is unknown, but given its situation as a settled village during that time, the habitat was probably already largely agricultural with remnant lowland forest.

Site 15—Mount Timpoong Peak, Mahinog Municipality, 5700 ft (ca. 1600 m) [approx. 9°11′N, 124°43.5′E]. Only a single specimen of *Suncus murinus* bears this locality. Given the restriction to Mahinog Municipality, the site must have been at the peak on the eastern side of the mountain, near to or including Site 8. The vegetation at this site would have been mossy forest, as described for Site 8.

Site 16—Mt. Mambajao, Mahidlaw, Catarman Municipality, 2500–3500 ft (ca. 800–1000 m) [approx. 9°9.5′N, 124°42.5′E] (24 and 26 May 1967). Only a few bats were collected at this site. Mt. Mambajao's highest peak is ca. 1600 m; this location in Catarman Municipality suggests that specimens were taken from the middle slopes, on the southern to southwestern flank of the mountain.

Site 17—Mt. Mambajao, Sangsangan, Catarman Municipality, 1400–3300 ft (ca. 400–1000 m) [approx. 9°9′N, 124°42.5′E] (14–31 May, 15 June 1967). Only mammals were collected at this site. This location suggests that specimens were taken on the lower to middle slopes of Mt. Mambajao, on the southern to southwestern flank of the mountain.

Site 18—Tag-ibo Cave, Catarman Municipality, 400 ft (ca. 100 m) (31 May 1967). A few bats were collected at this site, which we have been unable to locate. Because it was visited on the same day as specimens were obtained from Site 17, they are probably near each other.

Site 19—Mantigue Island [approx. 2 km N, 4 km E Mahinog; 9°10.5′N, 124°49.5′E] (28 June 1969). This site is a 4-ha coralline island, situated ca. 3 km east of Barangay Hubangon, Mahinog Municipality (Figs. 2 and 3). It was visited on 28 June 1969, and only White-collared Kingfisher (*Halcyon cloris*), Yellow-vented Bulbul (*Pycnonotus goiavier*), Pied Triller (*Lalage nigra*), and Olive-backed Sunbird (*Nectarinia jugularis*) were collected. The vegetation when it was visited in 1969 was most likely beach forest, with some disturbance.

Conservation

As documented by Balete et al. (2006), Heaney et al. (2006), and Tello et al. (2006), Camiguin supports at least 24 species of mammals and at least 54 species of birds, and additional fieldwork is likely to document the presence of additional species. This includes two species of mammals (in the genera *Apomys* and *Bullimus*) and one species of bird (genus *Loriculus*) that are unique to Camiguin; Camiguin is the smallest island in the Philippines currently known to support unique species of mammals (Heaney, 1986; Heaney et al., 1998) and is smaller than any island previously known to support an endemic bird (Peterson et al., 2000). The endemic species of mammals have been documented to occur in lowland, montane, and mossy forest from 1000 m to near the peaks but probably occur at lower elevations as well where we were unable to sample; the endemic bird (Tello et al., 2005) has been documented from ca. 300 to 1200 m, which

encompasses lowland and lower montane forest. The presence of these unique species, along with the frog and plants that are restricted to the island, have caused Camiguin to be listed as a key national and global priority site for conservation (Mallari et al., 2001; Heaney & Mallari, 2002; Ong et al., 2002) that was overlooked by previous assessments that were based on incomplete biological surveys (e.g., Hauge et al., 1986; Heaney, 1993; Peterson et al., 2000).

These diverse mammal and bird faunas originally occurred along the entire elevational and habitat gradient. The most fundamental requirement for their conservation is the continued existence of substantial areas of all original types of habitat in mature, good condition. The areas must be large enough for the existence of substantial populations, not just a few individuals, since populations often are vulnerable to extinction when they drop below about 1000 individuals (Primack, 1998).

Fortunately, Camiguin retains enough forest cover to make this possible, though there are a number of challenges to surmount. The results of the Swedish Satellite Survey of forest cover in 1987 (National Mapping and Resource Information Authority, 1988) showed a fairly large area of forest on Camiguin, mostly at upper elevations on Mt. Mambajao and Mt. Timpoong and associated highlands, as shown in Figure 2. Our surveys in 1994 and 1995 showed that much of that forest still remained, though the edges had been further degraded. Downslope, the degree of disturbance progressively increased so that little if any lowland forest remained in a primary condition; indeed, most had been replaced with coconut plantations, agricultural areas, and grassland. In 2001, it was estimated that 82% of the island, ca. 20,847 ha, was covered by croplands and other inhabited areas; almost half the island's area was covered with coconut plantations (http://agri10.norminet.org.ph/NMProfile/profile_camiguin.htm), leaving 18% as secondary and primary forest.

According to local residents, much of the forest on Camiguin was removed by commercial logging operations in the 1980s, with the logged areas subsequently being cleared for agriculture. During the 1990s, small-scale commercial logging, operating under salvage permits, was the main agent responsible for the continuing denudation of the areas below 1000 m. These salvage permits technically allowed only dead trees to be cut, but local residents told us that trees were often killed deliberately by the loggers so that they could then be cut down. Slash-and-burn agriculture (*kaingin*) of the remnant forest usually followed quickly (Heaney & Tabaranza, 1997). By the time we visited the island in 1995, areas below 300 m had no native forest, and only a little second growth remained up to ca. 800 m. Only the montane and mossy forest was in relatively good condition, but small-scale logging and kaingin was creeping farther up on the mountains; we noted a new kaingin at 1200 m on the side of Mt. Timpoong in 1995 (Heaney & Tabaranza, 1997; Mallari et al., 2000).

It is essential to note that conservation of the forest will have great benefits to the people of Camiguin as well as to the wildlife. The forest can serve as a permanent source of wood and other nontimber forest products to the local inhabitants if this is carefully managed. Perhaps most crucially, the forests of Camiguin provide the people with abundant water for domestic, agricultural, and industrial uses. As an additional essential ecological service, the forest helps prevent soil erosion and landslides. In early November 2002, about 200 human lives were lost and thousands of houses and other properties damaged by landslides during a typhoon, particularly in Mahinog. This disaster demonstrates the great economic and human cost of forest degradation. Additionally, the continued popularity of Camiguin as a tourist destination will rely strongly on its ability to provide beautiful scenery, attractive areas for hiking, fresh and clean water, and healthy coral reefs (which require low levels of siltation from adjacent rivers).

The importance of protecting the remaining forest of Camiguin can be appreciated when one considers its fast-growing population. In 1980, the population of Camiguin was about 57,000; two decades later, in 2000, the population had increased to more than 73,000; in 2020, it is projected to increase to 90,000 (http://www.popcom.gov.ph/sppr/statistics/leastvis_wesmin_northmin.htm). Consequently, the population density of Camiguin increased from 279 persons/km^2 in 1980 to 306 persons/km^2 in 2000; these were well above the national density of 160 persons/km^2 and 251 persons/km^2 in 1980 and 2000, respectively (http://www.popcom.gov.ph/sppr/statistics/lleastvisz_wesmin_northmin.htm; http://www.popcom.gov.ph/sppr/statistics/table3.htm).

In response to all these issues, including our discoveries in 1994–1995 of endemic species of mammals, the local government and Department

of Environment and Natural Resources (DENR) have moved steadily in recent years to have the upland areas where forest remains declared the "Timpoong–Hibok-hibok Natural Monument." At the time of this writing, the process of officially designating the protected area has reached the office of the secretary of the DENR and is expected to soon be endorsed to the president. If it is successful at that level, as is anticipated, it must then be voted on by the Philippine Congress for final designation, a process that may yet require several years. The approximate proposed boundary of the natural monument, with an area of 2,228 ha, plus a 1,423-ha buffer zone, is shown in Figure 2. Although both the location and area of forest and the natural monument as shown in Figure 2 are approximate, it is clear that the majority of the primary forest lies within the proposed boundaries of the park.

We fully endorse these recommendations and actions. But further, as part of this program of environmental protection and stabilization, we recommend the following to the local government of Camiguin and the Philippine DENR as essential activities: 1) continue and expand active enforcement efforts to protect existing forests, wildlife, and environment; 2) continue and expand current reforestation projects, using only native species of trees, not exotics, because the exotic trees do not provide habitat for the biodiversity of Camiguin and are injurious to the soil; 3) cancel existing salvage cutting permits for dead and fallen trees because these have often been abused; and 4) complete the process of declaring the remaining forest and key watershed areas a national protected area as soon as possible. To the maximum extent possible, all portions of the protected area should be connected by corridors of mature (or regenerating) habitat, especially along rivers and streams.

In connection with the above recommendations, it is essential to both wildlife conservation and watershed protection that national and local governments include substantial lowland areas (those below 800 m) in the proposed national park, regardless of the present condition of the habitats and vegetation, especially including all areas within 200 m of streams and rivers. We therefore recommend that the natural monument be expanded to include all good-quality secondary forest at all elevations and to include all major watercourses down to at least 600 m of elevation. This will enable future management to rehabilitate/restore lowland forest, which is one of the most critical habitats on Camiguin.

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2

A New Species of Forest Mouse, Genus *Apomys* (Mammalia: Rodentia: Muridae), from Camiguin Island, Philippines

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Abstract

An inventory of the mammals of Camiguin Island conducted in 1994 and 1995 documented the presence of a previously unknown species of Philippine forest mouse of the endemic Philippine genus *Apomys*, which is here named and described. Based on molecular data, the new species is most closely related to two species (*A. hylocoetes* and *A. insignis*) from Mindanao Island and to an unnamed species from Leyte, Biliran, and Bohol islands. The new species is diagnosed in comparison to its three closest relatives on the basis of slightly browner and less russet fur, slightly greater size overall, a moderately long and broad hind foot with small plantar pads, large tail scales, slightly narrower zygomatic width and mastoid breadth, deep rostrum of moderate length, a long orbit and braincase, narrow palate, large incisive foramina, short distance from the posterior edge of the incisive foramina to the anterior edge of the first upper molar, bony palate that extends well to the posterior of the posterior edge of the last upper molar, bullae that are more strongly oriented toward the cranial midline axis, third upper molar without a conspicuous anterolabial cusp, and a number of more subtle features. It is one of two species of mammals now known to be endemic to Camiguin, the other being *Bullimus gamay* (Rickart et al., 2002). Both are common in rain forest on Camiguin Island at upper elevations. The presence of two endemic mammals on this small (265 km^2) island is remarkable; there are no smaller islands in the Philippines known to support endemic mammal species.

Introduction

The Philippine Islands are notable for their large number of unique species of mammals; of 172 species known in 1998, 111 (64%) occurred nowhere else in the world, one of the greatest concentrations of unique mammalian diversity worldwide (Heaney et al., 1998). These species are usually not widely distributed within the Philippines but rather are confined to one or a few islands. Recent studies have shown that the geological history of the archipelago is largely responsible for the pattern of distribution, with most species of mammals found on only one of the several islands that formed during periods of low sea level in the late and middle Pleistocene. Each of these Pleistocene islands is surrounded by deep water (greater than 120 m current

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depth), and each has remained as an isolated oceanic island throughout its existence. However, though they are isolated by deep-water channels, the channels are not wide, usually not more than 25 km and often much narrower (Heaney, 1986, 1991, 1993, 2004; Heaney and Rickart, 1990; Heaney & Regalado, 1998).

Camiguin Island was noted by Heaney (1984, 1986) as an apparent exception to this pattern: collections made on Camiguin in the 1960s by field teams from Silliman University did not include any endemic mammals, even though the island seemed large enough to support them (Heaney, 1986, 2004). After the discovery of four endemic species on Sibuyan Island, another small oceanic island in the archipelago (Goodman & Ingle, 1993; Heaney et al., 1998), we suspected that the mammals of Camiguin might not have been fully surveyed, so we returned in 1994 and 1995 for further investigations (Heaney et al., 2004; Heaney & Tabaranza, 2006). In the course of those field studies, we documented the presence of two previously unknown species of mammals (Heaney & Tabaranza, 1997), *Bullimus gamay* (Rickart et al., 2002) and a species of forest mouse, genus *Apomys*. It is the purpose of this paper to describe this new species of forest mouse.

Materials and Methods

Specimens examined for this study are housed in the Delaware Museum of Natural History (DMNH), Field Museum of Natural History (FMNH), Mindanao State University–Iligan Institute of Technology (MSU-IIT), National Museum of the Philippines (NMP), University of Michigan Museum of Zoology (UMMZ), and United States National Museum of Natural History (USNM). Half the specimens from Camiguin now housed in FMNH will be sent to NMP. Material examined included specimens prepared as study skins with skulls (and some with postcranial skeletons), complete skeletons, and formalin-fixed specimens stored in 70% ethyl alcohol, many with skulls subsequently removed and cleaned. The following samples were examined: *Apomys hylocoetes*—Mindanao Island: Bukidnon Province: Mt. Kitanglad Range: 15 km S, 12.5 km W Dalwangan, elev. 2800 m, FMNH 148055; 16.5 km S, 4 km E Camp Phillips, elev. 1900 m, FMNH 147871–872, 148123–124; 18.5 km S, 4 km E camp Phillips, elev. 2250 m, FMNH 147874–876, 147880, 147900–904, 147906, 148125–128, 148132, 148135–138. *Apomys insignis*—Mindanao Island: Bukidnon Province: Mt. Kitanglad Range: 16.5 km S, 4 km E Camp Phillips, elev. 1900 m, FMNH 148152; 17 km S, 7 km E Baungon, elev. 1550 m, FMNH 146703; 18 km S, 7 km E Baungon, elev. 1800 m, FMNH 146704–710, 146712–714, 146716–718, 147088–089, 147091–092, 147094, 147098–099, 147102. *Apomys* sp.—Biliran Island: 3½ km S, 5½ km W Caibiran, elev. 700 m, UMMZ 160314, 160290, 160429–430; 4½ km S, 5 km W Caibiran, elev., 920 m, UMMZ 160290–291, 160315–316. Leyte Island: 9 km N, 3 km E Baybay, elev. 750 m, UMMZ 160318; 8½ km N, 2½ km E Baybay, elev. 500 m, UMMZ 160317, 160441. *Apomys* n. sp.—Holotype and referred specimens from Camiguin Island (see below).

Specimens were assigned to age categories as follows. Subadult animals are those that have not completed cranial growth, especially those having unfused basicranial sutures; these young animals have pelage that is usually softer and grayer than that of adults and are noticeably lower in weight, and females are usually nulliparous. Young adults are older; they have unworn adult pelage and have nearly completed cranial growth but have not yet reached adult weight and usually have not yet reproduced or are pregnant for the first time. Adults have completed cranial growth and have adult pelage, and usually the females are multiparous. Terminology for description of external features follows Brown (1971) and Brown and Yalden (1973). Terminology for cranial and dental features follows Musser and Heaney (1992). Scanning electron micrographs of skulls and teeth were made with uncoated specimens.

External measurements (total length, tail length, hind foot length, length of ear from notch, weight in grams) were taken from collectors' field catalogs or specimen labels. Fourteen cranial measurements (Table 1) were taken with digital calipers to the nearest 0.01 mm by Heaney; comparisons made in the text refer only to specimens also measured by Heaney.

Results

The endemic Philippine genus *Apomys* was described by Mearns (1905) to contain three species: *A. hylocoetes* (as the type species), *A.*

TABLE 1. Cranial and external measurements of *Apomys camiguinensis*, *A. hylocoetes*, *A. insignis*, and *A.* sp. (from Leyte and Biliran), in mm. Measurements, defined in the text, are given as mean ± 1 standard deviation, with ranges beneath, for adult males and females (with sample sizes indicated for each species and sex).

	A. camiguinensis		*A. hylocoetes*		*A. insignis*		*A.* sp. (Biliran + Leyte)	
Measurement	Males (6)	Females (4)	Males (12)	Females (14)	Males (12)	Females (13)	Males (5)	Females (4)
Basioccipital L	29.09 ± 0.49 28.59–29.24	28.27 ± 0.45(3) 27.84–28.74	28.79 ± 0.46 27.91–29.60	28.44 ± 0.65 27.14–29.58	27.97 ± 0.38 27.20–28.46	27.75 ± 0.63 26.80–28.55	25.28 ± 0.40 24.79–25.61	26.34 ± 0.44 25.93–29.93
Interorbital L	5.25 ± 0.14 5.08–5.39	5.24 ± 0.25 4.92–5.51	5.25 ± 0.20 4.97–5.56	5.18 ± 0.16 4.84–5.51	4.97 ± 0.18 4.60–5.28	4.97 ± 0.15 4.76–5.24	4.83 ± 0.11 4.69–4.99	4.88 ± 0.15 4.68–5.01
Zygomatic B	14.88 ± 0.31 14.41–15.20	14.95 ± 0.39 14.41–15.32	15.2 ± 0.25 14.91–15.77	15.02 ± 0.30 14.60–15.53	14.82 ± 0.37 13.97–15.47	14.74 ± 0.41 13.97–15.35	13.12 ± 0.43 12.61–13.47	13.75 ± 0.25 13.44–13.99
Mastoid B	12.84 ± 0.07(5) 12.75–12.93	12.43 ± 0.42(3) 11.95–12.74	13.07 ± 0.19 12.70–13.42	12.83 ± 0.30 12.46–13.29	12.45 ± 0.34 12.07–13.05	12.35 ± 0.24 12.03–12.95	11.85 ± 0.08 11.76–11.98	11.79 ± 0.32 11.47–12.11
Nasal L	11.36 ± 0.33 10.92–11.80	11.06 ± 0.49 10.48–11.67	12.54 ± 0.30 12.09–13.05	12.40 ± 0.50 11.33–13.19	11.64 ± 0.49 10.93–12.30	11.84 ± 0.53 11.47–13.13	10.33 ± 0.31(4) 9.88–10.59	10.68 ± 0.42 10.22–11.05
Ant. nasal B	3.80 ± 0.24 3.48–4.18	3.68 ± 0.14 3.51–3.84	3.84 ± 0.22 3.50–4.32	3.80 ± 0.24 3.22–4.05	3.79 ± 0.22 3.29–4.12	3.74 ± 0.21 3.48–4.11	3.32 ± 0.16(4) 3.23–3.55	3.59 ± 0.22 3.34–3.87
Rostral D	6.42 ± 0.17 6.18–6.69	6.26 ± 0.09 6.18–6.38	6.30 ± 0.15 6.04–6.46	6.25 ± 0.23 5.82–6.62	6.30 ± 0.17 5.97–6.56	6.32 ± 0.21 5.84–6.65	5.87 ± 0.19 5.62–6.03	6.13 ± 0.35 5.87–6.64
Rostral L	12.00 ± 0.31 11.57–12.48	11.61 ± 0.49 10.89–11.99	13.20 ± 0.42 12.43–13.78	13.10 ± 0.47 12.04–13.75	12.04 ± 0.35 11.54–12.73	12.05 ± 0.55 11.41–13.22	10.63 ± 0.26(4) 10.30–10.92	11.16 ± 0.19 10.87–11.27
Orbital L	10.22 ± 0.20 10.03–10.58	10.26 ± 0.31 9.95–10.67	9.99 ± 0.15 9.76–10.26	9.72 ± 0.23 9.35–10.20	9.96 ± 0.33 9.36–10.39	10.17 ± 0.22 9.78–10.56	9.24 ± 0.16 8.99–9.43	9.57 ± 0.28 9.16–9.76
Maxil. toothrow L	6.00 ± 0.10 5.82–6.37	6.04 ± 0.20 5.90–6.11	6.06 ± 0.32 5.61–6.33	6.04 ± 0.14 5.54–6.85	5.95 ± 0.22 5.87–6.34	5.29 ± 0.08 5.59–6.33	5.20 ± 0.17 5.17–5.37	6.04 ± 0.20 5.01–5.42
Palatal B at M1	6.45 ± 0.18 6.19–6.67	6.35 ± 0.11 6.27–6.51	6.52 ± 0.11 6.33–6.70	6.53 ± 0.18 6.42–6.85	6.64 ± 0.26 6.19–7.02	6.52 ± 0.26 6.16–6.94	5.77 ± 0.20 5.56–6.03	5.74 ± 0.18 5.57–5.99
Diastema L	7 .32 ± 0.21 6.91–7.54	7.33 ± 0.16 7.20–7.56	7.35 ± 0.23 7.03–7.65	7.30 ± 0.39 6.70–7.99	7.04 ± 0.29 6.69–7.58	6.98 ± 0.29 6.59–7.42	6.47 ± 0.18 6.27–6.66	6.84 ± 0.22 6.70–7.17
Total L	260.2 ± 4.4 254–266	253.8 ± 6.6 246–262	251.9 ± 6.3 240–260	247.8 ± 7.2 239–260	251.9 ± 10.3 231–266	251.8 ± 10.5 236–272	237.8 ± 6.3 231–247	245 ± 14.50(3) 230–259
Tail L	147.8 ± 7.4 140–160	146.3 ± 4.8 140–150	142.0 ± 5.2 133–150	140.5 ± 7.7 127–149	147.0 ± 4.4 139–154	146.4 ± 9.3 134–162	140.2 ± 5.1 135–146	145.0 ± 14.7(3) 132–161
Hind foot L	33.2 ± 0.4 (5) 33–34	32.5 ± 1.3 31–34	31.7 ± 1.20 29–33	31.6 ± 1.0 30–34	33.4 ± 0.8 32–35	32.8 ± 1.08 31–35	31.0 ± 0.70 30–32	30.0 ± 0.70(3) 29–32
Ear L	19.0 ± 0.00 (5) 19.0	19.0 ± 1.00(3) 18–20	20.3 18–22	20.1 ± 0.5 19–21	1.00 18–21	20.1 ± 0.5 18–20	19.8 ± 1.00(11) 18–19	19.3 ± 0.65 19–20
Weight (g)	41.1 ± 5.4 33–48.5	38.5 ± 3.5 34–42	39.5 ± 3.0 34–45	36.6 ± 2.6 33–40	37.8 ± 2.3 35–41	38.0 ± 5.7 33–52	27.8 ± 2.8 24–31	31.5 ± 3.7(3) 27–32

insignis, and *A. petraeus* (the last synonymized with *A. hylocoetes* by Musser, 1982), all from Mt. Apo, from which the name was derived. As related by Musser (1982), additional species were named from Luzon and Catanduanes, and the genus was found throughout much of the archipelago (Ruedas, 1995; Heaney et al., 1998). However, because the initial description was vague and many genera of Indo-Australian rodents poorly studied, *Apomys* was briefly synonymized with the genus *Rattus* at a time when most Indo-Australian murids were placed in that genus. Musser (1982) thoroughly redescribed *Apomys*, pointing out its many distinctive characters, and redefined the species then known. Musser and Heaney (1992) further defined and compared *Apomys* to other Philippine murids, and they pointed out its apparent close relationship to *Chrotomys, Celaenomys*, and *Rhynchomys*, also endemic to the Philippines. Using data from Musser and Heaney (1992), Heaney and Rickart (1990) postulated that *Apomys* was basal to the clade including *Chrotomys, Celaenomys*, and *Rhynchomys* and noted the diversification of this clade within the Philippines as an example of adaptive radiation. Heaney et al. (1998) noted the presence of many undescribed species of *Apomys*, including the species from Camiguin reported by Heaney and Tabaranza (1997).

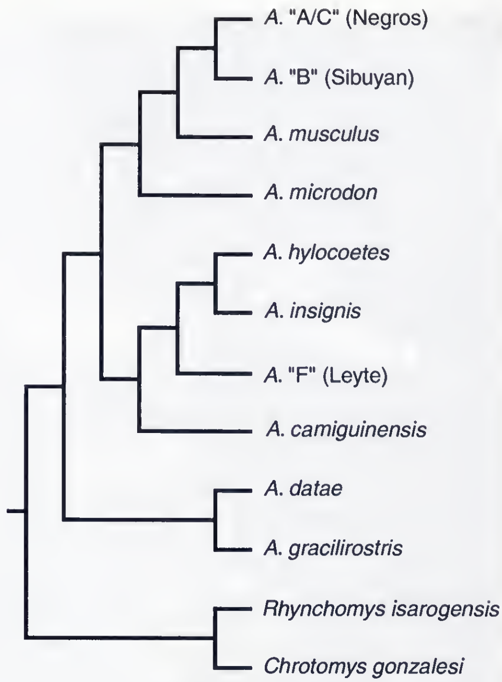

FIG. 1. Hypothesis of phylogenetic relationships within the genus *Apomys* based on parsimony analysis of cytochrome-b molecular data (based on Steppan et al., 2003).

Rickart and Heaney (2002) showed that *Apomys hylocoetes, A. insignis*, and the Leyte *Apomys* (as well as most others from Greater Luzon and Greater Negros-Panay) have distinctive karyotypes, but the *Apomys* from Camiguin has not been karyotyped. Steppan et al. (2003) used molecular data to assess phylogenetic relationships and geographic patterns of diversification within *Apomys*. Analysis of variation in cytochrome-b in 10 species (Fig. 1) showed the presence of three major clades: one containing *Apomys datae* and *A. gracilirostris*; a second clade containing *A. microdon, A. musculus*, and two undescribed species from Negros and Sibuyan (the "Greater Luzon, Mindoro, and Negros clade"); and a third clade containing *A. hylocoetes* and *A. insignis* from Mindanao, plus an undescribed species from Leyte, Biliran, and Bohol and another from Camiguin (the "Greater Mindanao clade"). The second and third of these three clades form a monophyletic clade that Musser (1982) described as being "species . . . of small or medium body size in which the canal for the internal maxillary artery [also described as the infraorbital branch of the stapedial artery] is partially open and part of the artery is exposed on the ventral surface of each pterygoid plate. That feature, combined with bright tawny upperparts, buffy underparts, brown or pale buffy feet, and patterning on the tail (usually monocolored or mottled, rarely sharply bicolored) suggest the five species [known in 1982] may be more closely related to each other than to any others in *Apomys*." Musser's (1982) recognition and diagnosis of this clade, based on very few specimens, was prescient and remains accurate. In the analysis by Steppan et al. (2003), the species from Camiguin is basal to the others in the "Greater Mindanao clade" (Fig. 1), and they estimated the time of divergence of the Camiguin mouse from the other members of its clade at about 2.3 million years ± about 25%.

We note that the *Apomys* from Biliran, Bohol, and Leyte (which we hereafter refer to as "the Leyte *Apomys*") was tentatively considered to represent either *A. microdon* (by Musser, 1982) or *A. littoralis* (Rickart et al., 1993; Heaney et al.,

FIG. 2. Photograph of an adult *Apomys camiguinensis*, taken on Mt. Timpoong, Camiguin Island, in March 1995.

1998), but the combination of the morphological data presented here, karyotypic data (Rickart & Heaney, 2002), and molecular data (Steppan et al., 2003) have led us to conclude that the Leyte *Apomys* is a distinct species; further details and description will be published elsewhere.

The specimens from Camiguin are morphologically similar to series of *A. hylocoetes* and *A. insignis* from Mindanao and the undescribed species from Leyte and Biliran but readily distinguished from all three of these species on the basis of external and cranial features. Heaney et al. (1998) and Steppan et al. (2003) referred to this animal informally as "*Apomys* sp. D." We now name the species from Camiguin as *Apomys camiguinensis*, new species.

Apomys camiguinensis, new species

Holotype—Adult male, FMNH 167878, collected 16 May 1994 by B. R. Tabaranza, Jr. Specimen originally fixed in formalin, transferred to 70% ethyl alcohol with skull removed and cleaned. Specimen is currently on deposit at FMNH and is to be transferred to NMP.

Type Locality—Barangay Kital-is, Sagay Municipality, 2 km N, 62 km W Mahinog, 1000 m elevation, Camiguin Province, Camiguin Island. 9°9.5′N, 124°43.5′E (see Heaney & Tabaranza, 2006, for further details).

Referred Specimens and Localities—In addition to the holotype, 19 paratypes are known from three localities ranging from 1000 to 1400 m (FMNH 154815–154816, 154854–154860, 167878–167882, plus 6 specimens at MSU-IIT); for localities, see Heaney et al. (2006). All were originally preserved in formalin and are now stored in ethyl alcohol, many with skulls removed and cleaned, or were prepared as complete skeletons. Tissue samples are housed at FMNH. Half of the specimens will be deposited at NMP.

Distribution—Known only from the upper elevations on Mt. Timpoong, Camiguin Island, but probably occurring throughout the montane and mossy rain forest on Camiguin Island (see fig. 2 in Heaney et al., 2004) and possibly at lower elevations.

Measurements—Table 1.

Etymology—The specific name refers to the sole island on which the species is found. We suggest the common English name "Camiguin forest mouse."

Diagnosis—A species of the genus *Apomys*, as defined by Musser (1982) and Musser and Heaney (1992), including the following distinctive generic features: rostrum long and moderately narrow; viewed laterally, rostrum with a rectangular shape, with premaxillaries projecting well anterior to the anterior edge of the upper incisors; incisive foramina broad relative to length; bony palate wide and long, densely pitted and perforated; upper third molar reduced to a large round peg; lower third molar also peg-like but retaining an anterior lamina, without evidence of the two cusps that usually form this lamina; occlusal surface of each first and second upper molar consisting of two simple chevron-shaped laminae followed by a small oval lamina, without evidence of cuspidation; auditory bulla separated from the squamosal and alisphenoid by a gap that is formed by the coalescence of the postglenoid foramen, the postalar fissure, and the middle lacerate foramen.

As described in more detail in the following section, the Camiguin mouse is defined by the following characters or unique combination of characters: moderate body size but somewhat robust build for the genus overall; the tail is long relative to body length, with unusually large scales, and more often with a sharp transition from dark brown dorsum to pale brown venter (i.e., sharply bicolored) than in other species; moderately long but unusually broad hind foot with small plantar pads, and slightly shorter ear. The pelage has more brown in the generally russet-brown dorsum than on its closest relatives and has more conspicuous salt-and-pepper speckling dorsally; the mystacial and genal vibrissae are long but moderate for the genus. The cranium has an unusually long braincase and orbit, somewhat narrow zygomatic and mastoid width, and a moderately long but deep and robust rostrum. The palate is rather narrow, the posterior edge of the palate extends unusually far posterior to the last molar, the incisive foramina long and wide, and the distance from the posterior edge of the incisive foramina is unusually short. The longest axis of the bullae is about 35° from the midline axis of the skull. The toothrows are of moderate size; the anterolabial cusp of the third upper molar is barely evident in most individuals.

Description and Comparisons—*Apomys camiguinensis* is an attractive mouse with large eyes and ears, long tail, and soft pelage (see Frontispiece, this volume, and Fig. 2). As with other members of the genus, the pelage is soft and dense, without spines or stiff hairs. The dorsal coloration is a rich brownish-russet with a small amount of salt-and-pepper speckling; underfur is pale slate-gray. The venter is paler, usually nearly white with a wash of buffy or pale russet, but some individuals have blazes of pure white (usually on the chest) or are much darker brown or russet-brown. There is a narrow area of bare skin around the eyes; the ears are moderately dark brown, with short hairs apparent on the outer surface, and present but tiny and nearly invisible on the inner surface. The mystacial vibrissae are long and conspicuous. The dorsal surface of the fore and hind feet are mostly buffy or pale brown but with a narrow band of scattered darker hairs around the midline, and these decrease in number and length toward the distal end of each foot (with only pale hairs on the dorsal surface of the toes). The feet are lightly pigmented or unpigmented on the ventral surface, with conspicuous plantar pads on the ventral surface (Fig. 3). The tail is long with conspicuous scales; fine hairs that are present between the scales are most visible on the dorsal and lateral surfaces and least visible ventrally. The tail is darker on the dorsal surface than on the ventral surface. The scrotum of adult males is fairly small and projects beyond the abdomen only partially on the posterior portion and has black or dark brown pigment at the posterior tip, about 3–5 mm in length. Females have two pairs of inguinal mammae.

Apomys camiguinensis is easily distinguished from most members of the genus by its intermediate size (only *A. insignis* and *A. hylocoetes* are similar) and from those two species by both external and cranial characters. *Apomys camiguinensis* has total length (average 254–260 mm) slightly greater than *A. hylocoetes* (248–252 mm) and *A. insignis* (251–252 mm) and substantially greater than the Leyte *Apomys* (238–245 mm; Table 1). The average tail length (146–148) is equal to that of *A. insignis* (147–148 mm), and substantially longer than that of *A. hylocoetes* (141–142 mm) and the Leyte *Apomys* (140–145 mm). The tail averages 57% of the total length in *A. camiguinensis*, compared

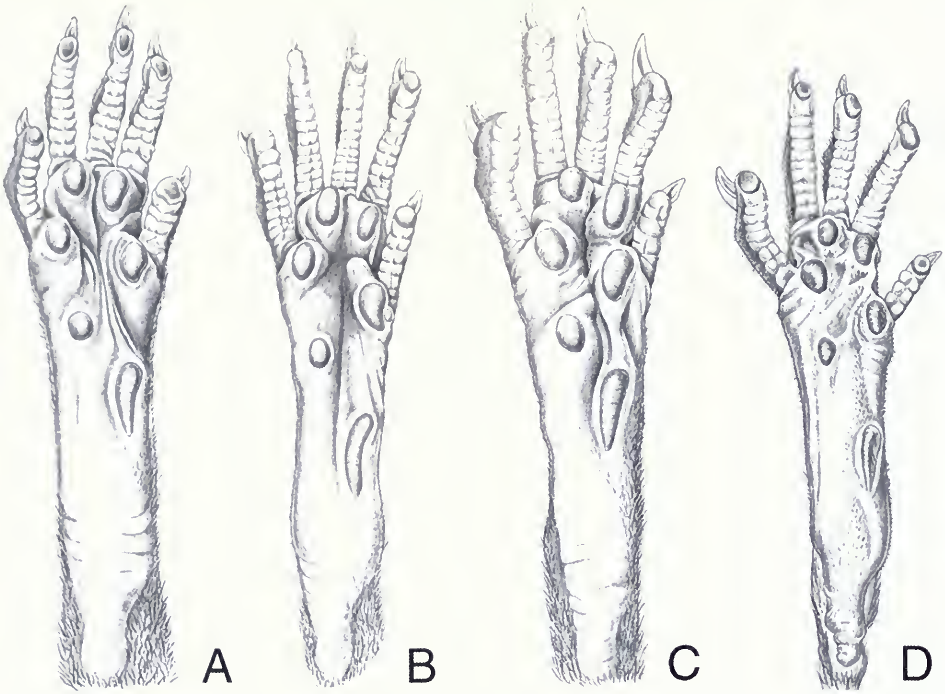

FIG. 3. Ventral surface of the right hind feet of (**A**) *Apomys camiguinensis*, (**B**) *A. hylocoetes*, (**C**) *A. insignis*, and (**D**) the undescribed *Apomys* from Leyte, all to roughly the same scale. Those of *A. hylocoetes* and *A. insignis* are redrawn from Musser (1982).

to 56.5% in *A. hylocoetes*, 58% in *A. insignis*, and 59% in the Leyte *Apomys*. The hind foot (about 33 mm) is about equal in length to that of *A. insignis* (33 mm) and is substantially longer than in *A. hylocoetes* (31–32 mm) and the Leyte *Apomys* (30–31 mm); the hind foot of *A. hylocoetes* is notably the broadest (Fig. 3; see also fig. 7 in Musser, 1982). Ear length is greatest in *A. hylocoetes* (20.2 mm), with *A. insignis* (19.5 mm), *A. camiguinensis* (19.0 mm), and the Leyte *Apomys* (18–19 mm) progressively slightly smaller (Table 1). The weight of *A. camiguinensis* (38–41 g) averages the greatest of the four, followed by *A. hylocoetes* (36–39 g), *A. insignis* (37–38 g), and the Leyte *Apomys* (28–31 g). In other words, the Camiguin *Apomys* is relatively heavy and long and has a relatively long tail (but slightly less long proportionately than some close relatives), a moderately long hind foot, and somewhat short ear.

The following qualitative external characters also distinguish *Apomys camiguineusis* from its three closest relatives. The dorsal coloration of the Camiguin mouse is less russet and more brown than in *A. hylocoetes* and *A. insignis*, with more of the salt-and-pepper appearance; the Leyte mouse is dorsally brighter red than the others, with more red and orange in the russet than the other three and almost no salt-and-pepper. Ventral coloration is generally similar in all four, though with the variation noted above, but *A. hylocoetes* tends to have more of an orange wash than the others. The dorsal surface of the hind feet usually is palest in the Leyte mouse and darkest in the Camiguin mouse. The mystacial vibrissae are long on all four species but longest on *A. insignis* (up to 56–60 mm maximum), on which they reach past the middle of the back, and intermediate on the Camiguin mouse (52–55 mm), *A. hylocoetes* (51–55 mm), and Leyte mouse (50–55 mm). Genal vibrissae reach to the anterior edge of the largest lateral pad on the Camiguin and Leyte mice but farther forward, to the base of the toes, on *A. hylocoetes* and *A. insignis*.

The hind foot (Fig. 3) differs markedly among the four. The foot of *A. camiguinensis* is about the same length as that of *A. hylocoetes* but is broader and has smaller plantar pads. The hind foot of the Leyte mouse is proportioned similarly

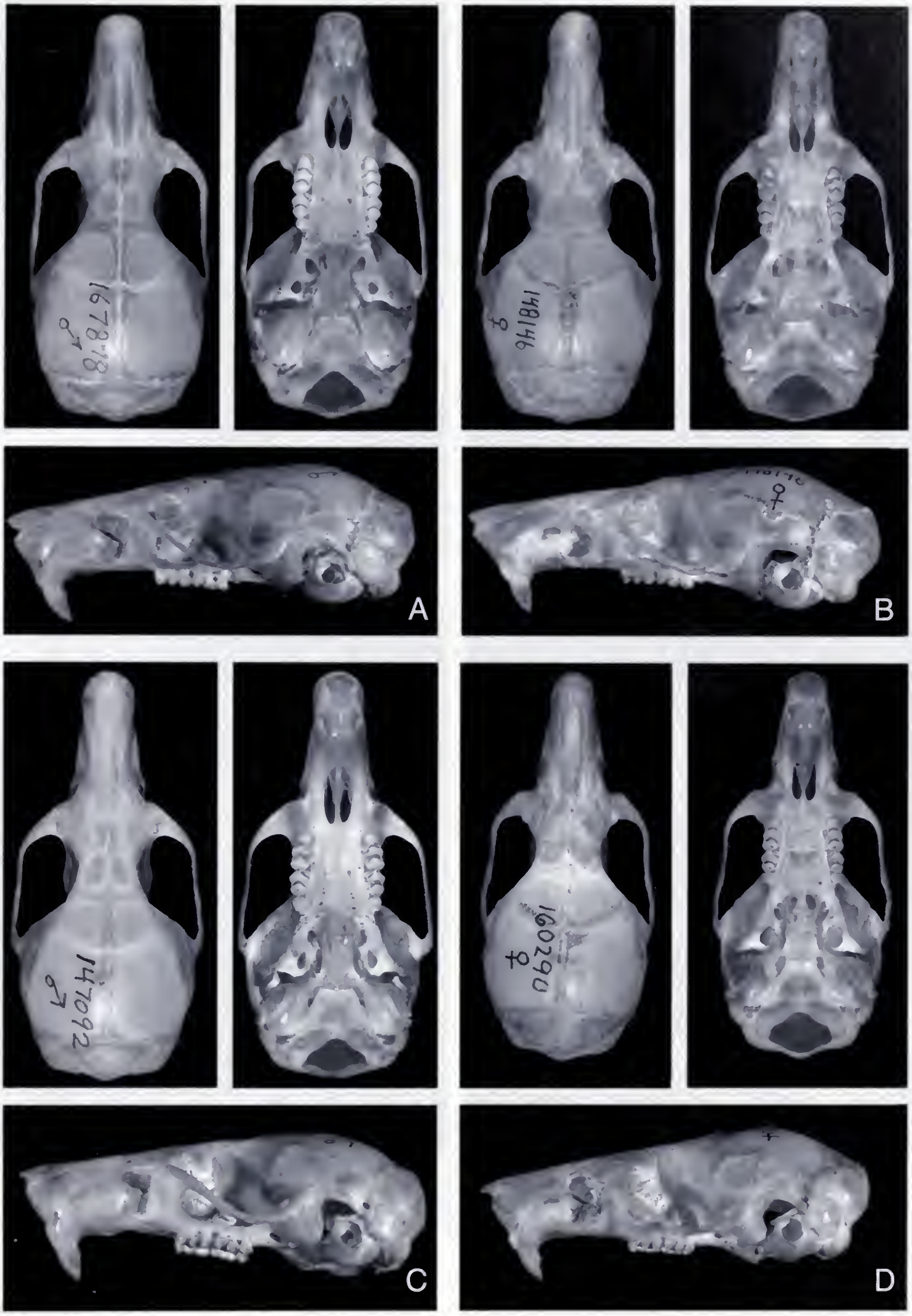

FIG. 4. Photographs of dorsal, ventral, and lateral views of the crania of *Apomys camiguinensis* (**A**; FMNH 167878, holotype), *A. hylocoetes* (**B**; FMNH 148146), *A. insignis* (**C**; FMNH 147092), and the undescribed *Apomys* from Leyte (**D**; UMMZ 160290), all to the same scale.

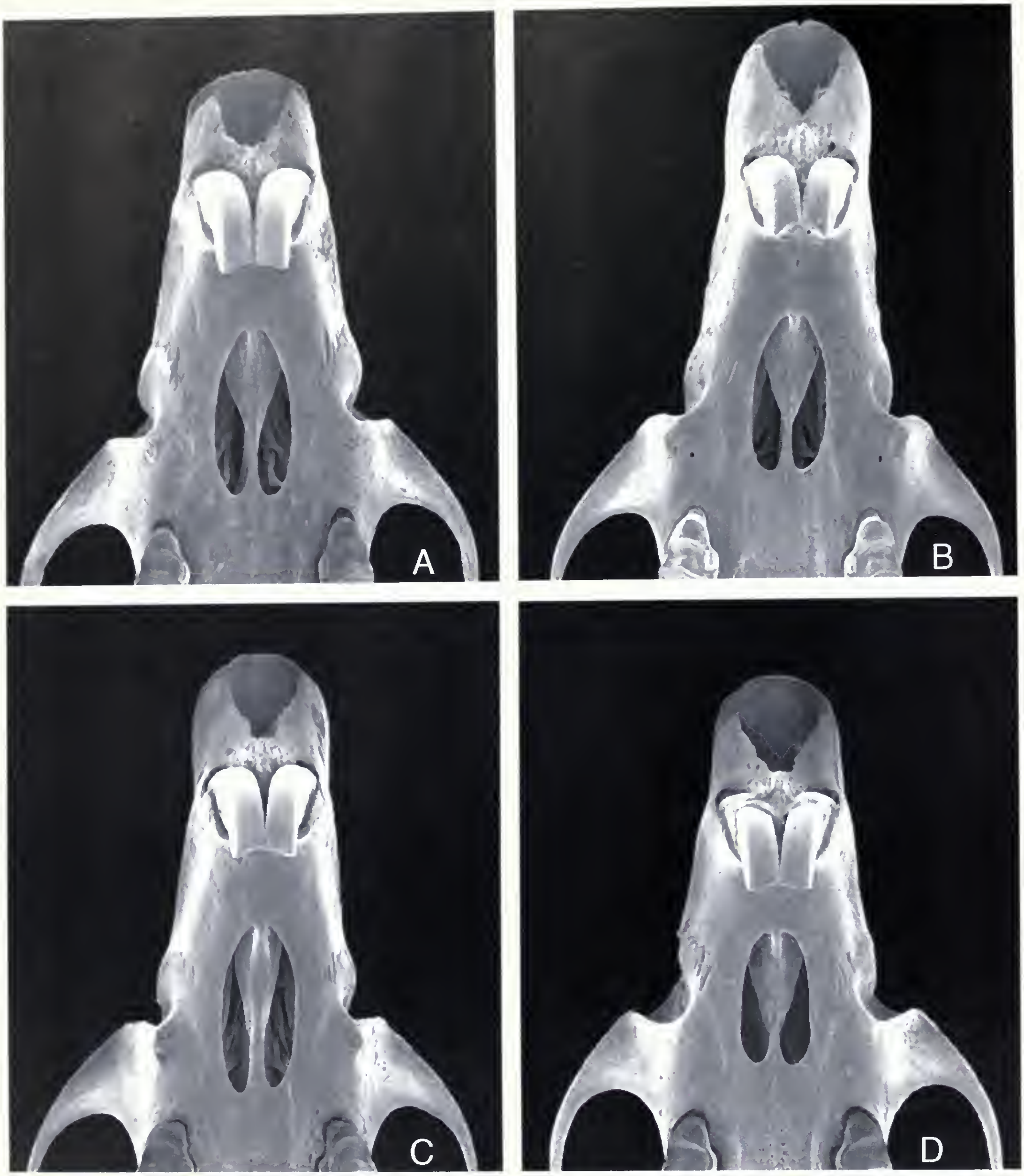

FIG. 5. Scanning electron micrographs of the ventral view of the anterior portion of the skulls of *Apomys camiguinensis* (**A**; FMNH 167878, holotype), *A. hylocoetes* (**B**; FMNH 148146), *A. insignis* (**C**; FMNH 147092), and the undescribed *Apomys* from Leyte (**D**; UMMZ 160290), all to same scale.

to *A. hylocoetes* but is smaller. The hind foot of *A. insignis* is very long and narrow, with plantar pads of moderate size. On all species, the claws on all five digits are unpigmented and laterally compressed. On *A. camiguinensis*, the claws are sturdy and sharply pointed; those of *A. hylocoetes* are slightly thinner and more sharply pointed and the digits bearing them slightly more slender. The digits and claws of *A. insignis* are shorter and more slender; the digits and claws of

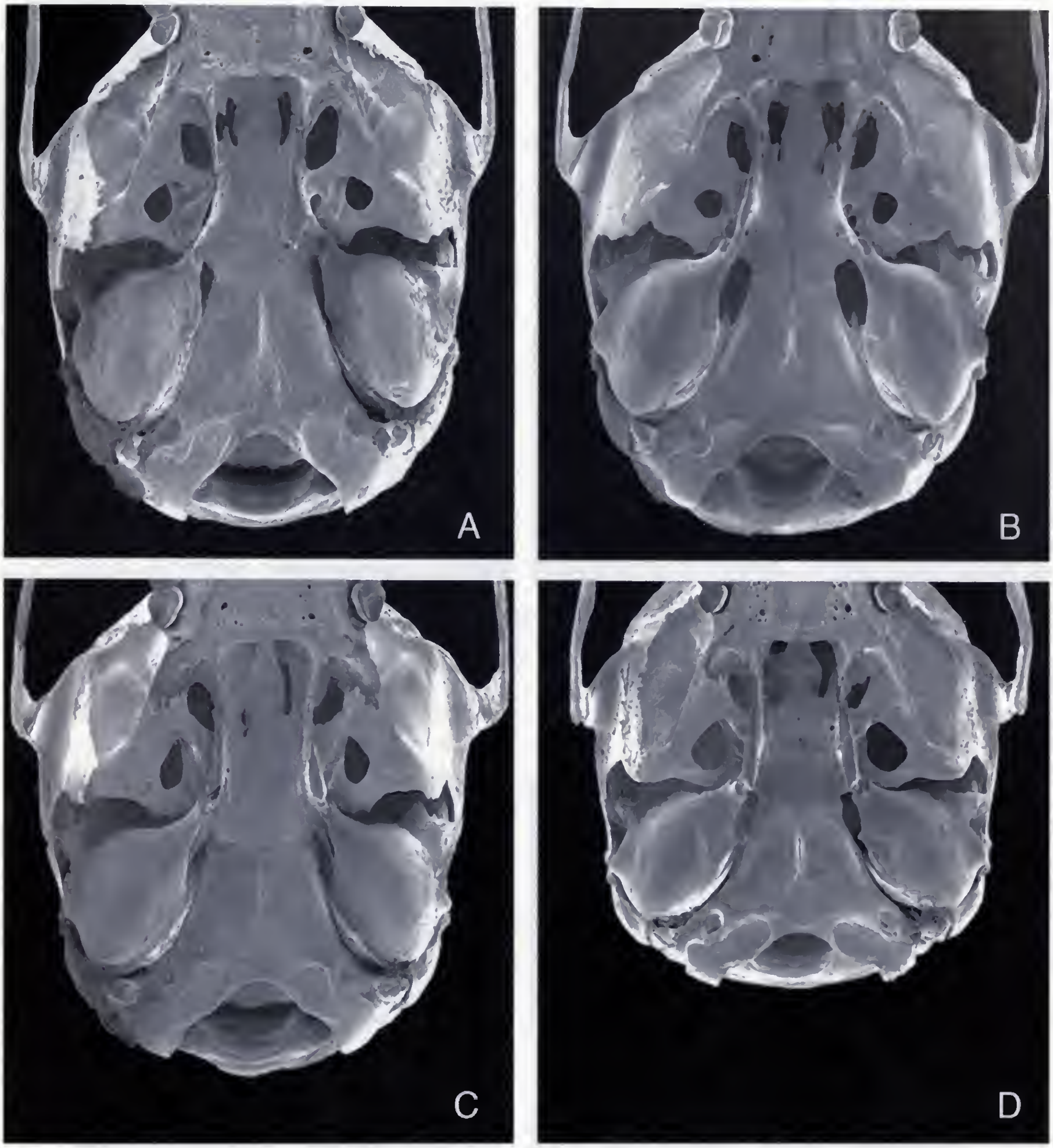

FIG. 6. Scanning electron micrographs of the ventral view of the posterior portion of the skulls of *Apomys camiguinensis* (**A**; FMNH 167878, holotype), *A. hylocoetes* (**B**; FMNH 148146), *A. insignis* (**C**; FMNH 147092), and the undescribed *Apomys* from Leyte (**D**; UMMZ 160290), all to same scale.

the Leyte mouse are still smaller and more slender. The forefeet of *A. camiguinensis* have smaller pads than those of the others (but only proportionately in the case of the generally smaller Leyte mouse), but the feet are slightly broader and more robust than in the other species. All four species have a flat, unpigmented nail on the pollex. The relative size and thickness follows the same pattern as the hind feet, with *A. camiguinensis* being the most robust, *A. hylocoetes* slightly shorter and thinner, *A. insignis* much shorter and more slender, and the Leyte mouse much like *A. insignis* but a bit smaller overall.

The tail scales on the Camiguin mouse are largest, with 12–12.5 scales/cm near the base, compared to 14–15 scales/cm in *A. hylocoetes*, 13–14 in *A. insignis*, and 13–15 in the Leyte

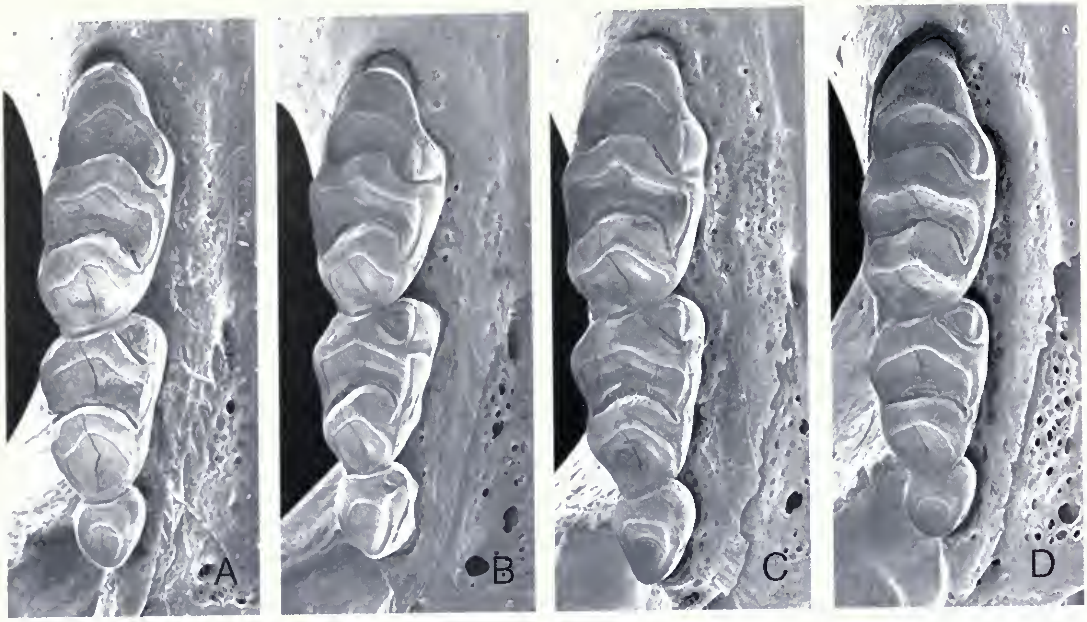

FIG. 7. Scanning electron micrographs of the occlusal surface of the maxillary toothrows of *Apomys camiguinensis* (**A**; FMNH 167878, holotype), *A. hylocoetes* (**B**; FMNH 148146), *A. insignis* (**C**; FMNH 147092), and the undescribed *Apomys* from Leyte (**D**; UMMZ 160290), all to same scale.

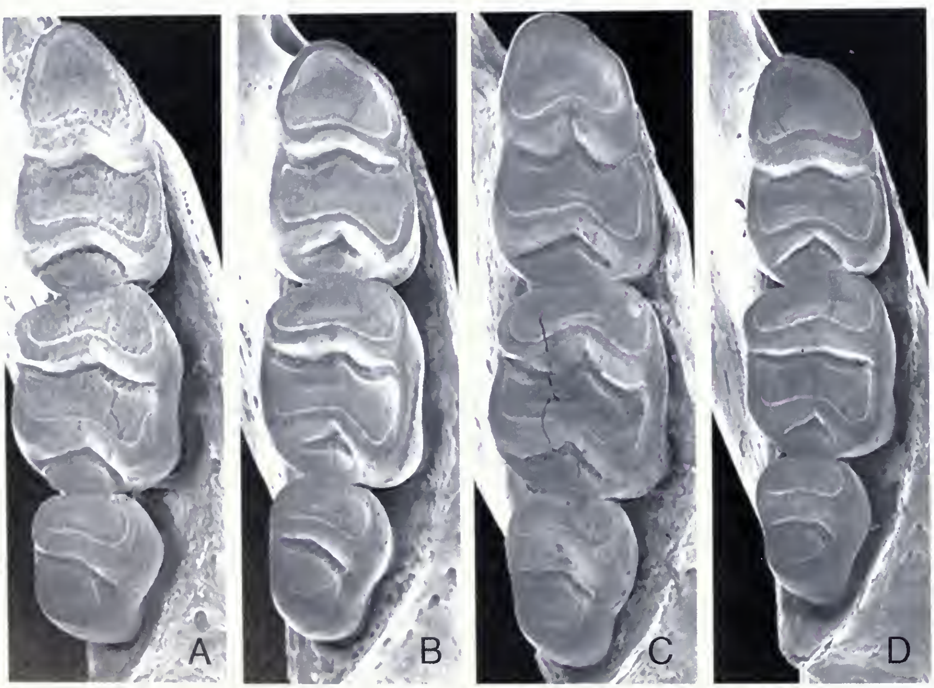

FIG. 8. Scanning electron micrographs of the occlusal surface of the mandibular molariform toothrows of *Apomys camiguinensis* (**A**; FMNH 167878, holotype), *A. hylocoetes* (**B**; FMNH 148146), *A. insignis* (**C**; FMNH 147092), and the undescribed *Apomys* from Leyte (**D**; UMMZ 160290), all to same scale.

mouse. The size of the scales remains about the same more distally on a given species to about the midpoint; from there to the tip scale size decreases, mostly in the last quarter of the length, to about half the length (and one-fourth the size) of scales near the base of the tail. The scales of the tail are dark brown dorsally and nearly white ventrally on all four species, but the transition is most often an abrupt line on the Camiguin mouse, often producing a sharply bicolored tail, and most often gradual on the other three species. Typically, three hairs grow from beneath each scale, projecting only slightly laterally from the tail; on the basal quarter of the tail, one of the three hairs is missing from a given scale about one-third of the time. On *A. camiguinensis*, the hairs are about one and one-third the length of a scale near the base of the tail, have about the same length 25% toward the tip, are slightly longer at the midpoint, are about one and two-thirds the length of a scale 75% toward the tip, and are about five times the length of a scale near the tip, where scale length has been reduced by about half relative to the base. On *A. hylocoetes*, hairs are about one and a half the length of a scale near the base of the tail, are similar 25% toward the tip, are about twice the length of a scale near the midpoint, are about two and a half times the length of a scale 75% toward the tip, and are more than five times the length of a scale near the tip. On *A. insignis*, hairs are one and one-third a scale length near the tail's base, similar at 25%, one and two-thirds near the midpoint, about two and one-half of a scale length near 75%, and about three and one-half the length of a scale near the tip. On the Leyte mouse, tail hairs are slightly less than the length of a scale near the base of the tail, similar at the midpoint and at 75%, and about two times the length of a scale near the tip. In all four species, the hair becomes slightly greater in diameter distally than it is proximally; combined with the trend for greater length, this means that the tail become more heavily covered with hair distally. None of the species shows elongated hairs at the very tip of the tail (i.e., there is no "pencilling"). Hairs on the dorsal surface are more heavily pigmented dorsally than ventrally in all four species. On adults of all four species, the dorsal surface of the tip (2–5 mm) of the tail becomes worn, with most scales and many hairs absent, leaving a smooth, leathery surface.

The cranium of *Apomys camiguinensis* (Figs. 4–6) has basioccipital length (28.3–29.0 mm) slightly greater than that of *A. hylocoetes* (28.3–28.8 mm), clearly more than *A. insignis* (27.8–28.0 mm) and substantially more than the Leyte *Apomys* (25.3–26.3 mm); the interorbital width is proportioned similarly (Table 1). Zygomatic breadth averages greatest in *A. hylocoetes* (15.0–15.2 mm), followed by *A. camiguinensis* (14.9–15.0 mm), *A. insignis* (14.7–14.8 mm), and the Leyte *Apomys* (13.1–13.7 mm), with mastoid breadth following the same pattern (Table 1). Nasal length averages substantially greater in *A. hylocoetes* (12.3–12.5 mm) than in *A. insignis* (11.6–11.9 mm), *A. camiguinensis* (11.1–11.4 mm), or the Leyte *Apomys* (10.3–10.7 mm), and anterior nasal breadth is similarly patterned (Table 1). Rostral depth averages greatest in *A. camiguinensis* (6.3–6.4 mm), with *A. hylocoetes* (6.2–6.3 mm) and *A. insignis* (6.3 mm) slightly less deep and very similar to each other and the Leyte *Apomys* generally less deep (5.9–6.1 mm). Rostral length (Fig. 5) is clearly greatest in *A. hylocoetes* (13.1–13.2 mm), with *A. camiguinensis* (11.6–12.0 mm) and *A. insignis* (11.9–12.0 mm) similar to each other but much greater than the Leyte *Apomys* (10.6–11.2 mm). Orbital length averages greatest in *A. camiguinensis* (10.2–10.3 mm), followed by *A. insignis* (10.0–10.2 mm) and *A. hylocoetes* (9.7–10.0) and the small Leyte *Apomys* (9.2–9.6). To summarize, *A. camiguinensis* is characterized by the longest skull and deepest rostrum, but *A. hylocoetes* has slightly greater zygomatic and mastoid width as well as greater nasal length and breadth and rostral length. Although the rostrum of *A. camiguinensis* is moderate in length, the orbital region and braincase are unusually long. The cranium of *A. insignis* tends to be smaller but generally similarly proportioned to *A. camiguinensis*, and the Leyte *Apomys* is smaller in all dimensions, though it seems to follow the pattern of *A. camiguinensis* and *A. insignis*.

The maxillary toothrow (Fig. 7) of *A. camiguinensis* (6.0 mm) averages nearly identical in length to that of *A. hylocoetes* (6.0 mm) and *A. insignis* (6.0 mm), and all are much greater than that of the Leyte *Apomys* (5.2–5.3 mm). Palatal breadth at M^1 (Fig. 4) is greatest in *A. insignis* (6.5–6.6 mm), followed by *A. hylocoetes* (6.5 mm) and *A. camiguinensis* (6.3–6.5 mm) and the Leyte *Apomys* (5.7–5.8 mm). Diastema length (Figs. 4 and 5) in *A. camiguinensis* (7.3 mm) averages slightly greater than in *A.*

hylocoetes (7.2–7.3 mm), more than *A. insignis* (7.0 mm), and least in the Leyte *Apomys* (6.5–6.8 mm). In other words, the maxillary toothrows of the three larger *Apomys* are all similar, with the Leyte *Apomys* having disproportionately short toothrow, but the palate of *A. camiguinensis* is disproportionately narrow (as is that of the Leyte *Apomys*), and that of *A. hylocoetes* is disproportionately wide.

In addition, we note the following qualitative characters. The incisive foramina (Fig. 5) are widest in *A. camiguinensis* and in *A. hylocoetes* and longest in *A. camiguinensis* and *A. insignis*, so that the area of the foramina is greatest in *A. camiguinensis*. The distance from the posterior edge of the incisive foramina to a line between the anterior edges of the first maxillary molar is shortest in *A. camiguinensis*, slightly greater in *A. insignis*, and longest in *A. hylocoetes* and the *Apomys* from Leyte. The braincase of *A. camiguinensis* is slightly more elongate and that of the Leyte *Apomys* proportionately most squarish among the four species (Fig. 6). The posterior edge of the bony palate (Fig. 6) extends farthest posterior to the posterior edge of the last maxillary molar in *A. camiguinensis*, slightly less far in *A. hylocoetes* and the *Apomys* from Leyte, and least far in *A. insignis*. The long axis of the bullae (Fig. 6) is about 45° from the cranial midline axis in the *Apomys* from Leyte, about 40° in *A. hylocoetes* and *A. insignis*, and about 35° in *A. camiguinensis*. The hard palate of *A. hylocoetes* and the Leyte *Apomys* are usually most heavily pitted and perforated with vacuities and *A. camiguinensis* and *A. insignis* less so (Figs. 4 and 7). The third upper molar (Fig. 7) has an anterolabial cusp (probably t1; see Musser & Heaney, 1992, p. 65) that is well developed in *A. hylocoetes*, less conspicuous in *A. insignis*, and barely evident in *A. camiguinensis* and the *Apomys* from Leyte. The first upper molar of *A. hylocoetes* tends to have a more conspicuous anterolingual cleft than do the other three species (Fig. 7). Both upper and lower toothrows of *A. insignis* are the most massive (Figs. 7 and 8), with *A. camiguinensis* somewhat less massive, *A. hylocoetes* substantially less so, and the *Apomys* from Leyte smallest overall. All four species have the canal for the infraorbital branch of the stapedial artery partially open and part of the artery exposed on the ventral surface of each pterygoid plate (Fig. 6), as noted by Musser (1982).

Ecology—See Heaney et al. (2006) for ecological information.

Discussion

The presence of *Apomys camiguinensis* as an endemic species on a small island, along with the additional murine rodent *Bullimus gamay* (Rickart et al., 2002) and the Hanging-Parrot (*Loriculus* sp., described in this volume), as noted above, clearly indicates the importance of Camiguin Island as a unique center of biological diversity that is worthy and in need of conservation (Heaney & Tabaranza, 2005). In addition, the distinctiveness of this species confirms predictions made on the basis of biogeographic models (Heaney, 2004) of the expected presence of endemic small mammals on Camiguin. Further studies of the mammals, birds, and other organisms are clearly warranted to determine, for example, the degree of genetic difference from closest relatives (most of which occur on Mindanao) as a means of assessing the role of colonization and gene flow in determining patterns of species richness and endemism in the Philippines. In other words, Camiguin represents a natural experiment, as a young oceanic, volcanic island that is near to a large, rich source of species (Mindanao), in which we can measure the impact of genetic isolation in animals and plants of varying vagility under standardized conditions. Such studies are certain to produce new insights into the process by which biological diversity is generated in the Philippines and in other oceanic archipelagos.

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3

Synopsis and Biogeography of the Mammals of Camiguin Island, Philippines

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Abstract

Biodiversity surveys in the 1960s and 1990s on Camiguin Island, a geologically young, volcanically active oceanic island surrounded by deep water, have demonstrated the presence of 24 species of land mammals. Three species (one insectivore and two rodents) are not native to the Philippines, but all others (one insectivore, 12 bats, one monkey, four rodents, two small carnivores, and one ungulate) are indigenous. Among those captured in the 1990s were two previously unknown species of murid rodents in the genera *Apomys* and *Bullimus* that are endemic to Camiguin. The discovery of two new species on such a small island (ca. 265 km^2) is remarkable; Camiguin is currently the smallest island in the Philippines known to have unique species of mammals. Total species richness of nonvolant mammals on Camiguin is low, but relative to islands that were once part of Pleistocene Greater Mindanao, Camiguin is not depauperate. However, its fauna is not ecologically balanced in the same way as the faunas of the islands that were part of Greater Mindanao: ground-living shrews (*Crocidura*) and rodents (*Apomys*, *Bullimus*, *Crunomys*, and *Rattus*) from lowland forest, along with some large mammals (*Macaca*, *Paradoxurus*, and *Sus*) are well represented on Camiguin, but all the arboreal small mammals that characterize lowland forest on Mindanao (*Sundasciurus*, *Exilisciurus*, *Cynocephalus*, and *Tarsius*), ground-living small mammals from montane habitats (*Urogale*, *Podogymnura*, *Batomys*, *Limnomys*, and *Tarsomys*), and one large mammal (*Cervus*) are absent. Additionally, at least two genera of fruit bats (*Haplonycteris* and *Megaerops*) that are fairly common in lowland rain forests on Mindanao are absent on Camiguin. The presence of some nonvolant mammals demonstrates that dispersal across the deep but narrow intervening channel takes place, but the presence of two species endemic to Camiguin and the absence of other species that are present on nearby Mindanao implies that dispersal probably is rare. The Asian house shrew (*Suncus murinus*) was remarkably abundant in primary forest at high elevation; this species has also been found to be abundant in montane primary forest on Negros Island, which also has low total species richness. Species richness of small nonflying mammals was greatest at fairly high elevation.

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Introduction

The Philippine Islands present a remarkable theater for the study of the ecology and evolution of mammalian diversity. Its islands range in size from less than one hectare to over 100,000 km^2, with geological age varying from under 1 million

years to over 40 million years. These islands represent many sets of historically distinct geological units of remarkably varied origins; some had land-bridge connections to the Asian mainland in the past (those of the Palawan group), but most are purely oceanic in origin (Heaney, 1986, 1991b, 2000; Heaney & Rickart, 1990; Hall, 1998, 2002). The mammals that have evolved in this diverse archipelago include at least 111 species endemic to the archipelago out of 172 native terrestrial species; with endemism at 64%, the Philippine fauna is one of the most distinctive in the world (Mittermeier et al., 1997, 1999; Heaney & Regalado, 1998). While most of the endemic species occur on the large islands of Luzon, Mindanao, Mindoro, Negros, and Palawan (e.g., Heaney, 1986, 1993, 2000; Heaney et al., 1998; Rickart et al., 1998), significant numbers occur on the smaller islands as well, especially those surrounded by deep water (e.g., Heaney, 1986, 2004; Goodman & Ingle, 1993; Heaney & Tabaranza, 1997; Musser et al., 1998).

As noted by Heaney and Tabaranza (2006a), Camiguin, an island of 265 km^2 located about 10 km north of Mindanao in the Bohol Sea, is one such deep-water island, with a minimum depth to Mindanao of 385 m. It is steeply mountainous, with several active volcanic cones that reach to a maximum elevation of about 1600 m. A series of biological surveys on Camiguin in the late 1960s that focused on birds (see Balete et al., 2006) also yielded some mammal specimens, and an earlier report on those surveys (Heaney, 1984) concluded that the island had no endemic mammal species and was depauperate. Subsequent studies on other islands made us suspect that those earlier surveys were incomplete because so few mammal species had been obtained and because the number of nonvolant mammal specimens was small (thus indicating limited sampling effort). Further, on the basis of biogeographic patterns elsewhere in the Philippines, we predicted the presence of several endemic small mammals on Camiguin (Heaney, 2004). To investigate the hypotheses that the previously measured species richness was low because of incomplete surveys and that about two endemic species should be present, we returned to Camiguin briefly in 1992 and more extensively in 1994 and 1995 to conduct additional mammal inventories in all the major habitats along the elevational gradient, especially by trapping small mammals at higher elevations where there were few records from the 1960s. As indicated in a brief preliminary report (Heaney & Tabaranza, 1997), we found eight additional species on the island that are widespread in the Philippines, plus two previously unknown endemic species of rodents. The purpose of this paper is to summarize the results of the 1994 and 1995 mammal surveys and integrate those data with information from the 1960s, including information on habitat associations, relative abundance, and ecology of the species.

Methods

Prior Reports

The first report of mammals from Camiguin Island was that of Gray (1843), who reported *Paradoxurus hermaphroditus*. Three field teams from Silliman University led by Dioscoro S. Rabor collected mammals on Camiguin in 1967, 1968, and 1969; specimens were deposited at the Delaware Museum of Natural History (DMNH) and Royal Ontario Museum (ROM); for details, see Heaney and Tabaranza (2006a). Several specimens were reported by Peterson and Fenton (1970); all known specimens from the 1960s were examined and summarized by Heaney (1984). All data included in this paper from the 1960s specimens are based on data in Heaney (1984), except as noted below.

Recent Data

Field studies were conducted during three periods in 1992, 1994, and 1995; general methods and site descriptions are given in Heaney and Tabaranza (2006a). Sampling during 1995 followed methods used on Leyte, Luzon, Negros, and other islands (Heaney et al., 1989, 1999; Rickart et al., 1991, 1993) to facilitate quantitative comparisons. Nonvolant small mammals were caught in traps; during 1995, all traps were Victor rat snap traps. Most were baited with fresh fried coconut coated with peanut butter, but a few were baited with live earthworms. During 1994, several National live traps were used, in addition to Victor rat traps, and were baited with coconut bait. Bats were captured in 12-m mist nets. Voucher specimens were prepared in fluid or as skeletons and have been deposited at The Field Museum of Natural History (FMNH), National Museum of the Phi-

lippines (NMP), and Mindanao State University–Iligan Institute of Technology (MSU-IIT). Most specimens were autopsied for reproductive information. The size of embryos was measured as crown to rump length (CRL). Subadult animals are defined here as those that have not completed cranial growth, especially those having unfused basicranial sutures; these young animals have pelage that is usually softer and grayer than that of adults and are noticeably lower in weight and females are usually nulliparous. Young adults are older; they have nearly completed cranial growth but have not yet reached adult weight and, usually, have not yet reproduced or are pregnant for the first time. Adults have completed cranial growth and adult pelage, and usually the females are multiparous. Comments on distribution and use of scientific names are based on Heaney et al. (1998) unless additional sources are mentioned. Records of specimens examined are summarized at the end of each account; such summaries include site number and the number of specimens (in parentheses).

External measurements and weights reported here were taken in the field by members of the field team on fresh animals. Cranial measurements were taken by Heaney with digital calipers graduated to 0.01 mm. Comparisons of cranial measurements are to published records of specimens measured in the same manner by Heaney.

Accounts of Species

Order Insectivora

Family Soricidae—Shrews

Crocidura beatus Miller, 1910

The Mindanao shrew is widespread on islands in the Mindanao Faunal Region (Heaney & Ruedi, 1994; Heaney et al., 1998); these are the first records from an island that was not part of the late Pleistocene island of Greater Mindanao (Heaney, 1986). This shrew has most often been found in primary forest, especially at higher elevations; is usually uncommon in secondary forest; and is absent outside of forest (Heaney et al., 1989; Rickart et al., 1993).

Crocidura beatus was trapped on Camiguin at three forest sites in May 1994 and March 1995 (Fig. 1, Table 1). It was uncommon in secondary lowland forest at 1000 m elevation (Site 4), in disturbed lower montane forest at 1200 m elevation (Site 5), and in primary montane forest at 1275 m (Site 7). It was most often trapped under tree roots and live vegetation. None were taken in agricultural areas at 150 m (Site 3), or in mossy forest at 1475 m (Site 8, where there was limited sampling; Table 1). This use of habitat is consistent with data from islands on Greater Mindanao (Rickart et al., 1993; Heaney et al., unpubl. data).

In 1994 and 1995, three adult females were trapped; one was pregnant with a single embryo (CRL = 10 mm). A multiparous, nonpregnant female weighed 13 g; an adult male weighed 7 g. Both cranial and external measurements (Table 2) are within stated ranges for Mindanao (Heaney & Ruedi, 1994) but are slightly smaller than those of series taken on Biliran, Leyte, and Maripipi (Rickart et al., 1993).

SPECIMENS EXAMINED—Total 5. Site 4 (2 FMNH, 1 MSU-IIT); Site 5 (1 FMNH); Site 7 (1 FMNH).

Suncus murinus (Linnaeus, 1766)

The Asian house-shrew occurs widely in Asia and Indo-Australia; it now occurs throughout the Philippines, though it is not native to the country. It is abundant in urban and agricultural areas; on islands with low mammal species richness such as Negros, it is sometimes abundant in disturbed forest and occasionally in primary forest (Heideman et al., 1987; Heaney et al., 1989, 1991), but on islands of average species richness, it is usually rare or absent from forest (Heaney et al., 1989, 1998, unpubl. data; Rickart et al., 1993).

A single subadult specimen from Mt. Timpoong Peak was available previously (Heaney 1984). In 1994–1995, we captured this species from 150 to 1475 m, and it was the most common species at the three highest sites, all in primary forest (Table 1, Fig. 1). It was especially abundant in montane forest at 1275 m (Site 7). It was moderately abundant in primary mossy forest (Site 6; elev. 1300 m) and in lower mossy forest at 1475 m elevation (Site 8) but was much less common in heavily disturbed lowland agricultural land at 150 m (Site 3). This pattern of abundance is quite different from that on the species-rich islands of Biliran, Leyte, Luzon, Maripipi, and Mindanao, where specimens were never caught in primary forest (Heaney et al., 1989, 1999, unpubl. data; Rickart et al., 1993) but similar to the species-poor island of Negros, where *S. murinus* was abundant in transitional mossy/montane forest and in mossy forest at

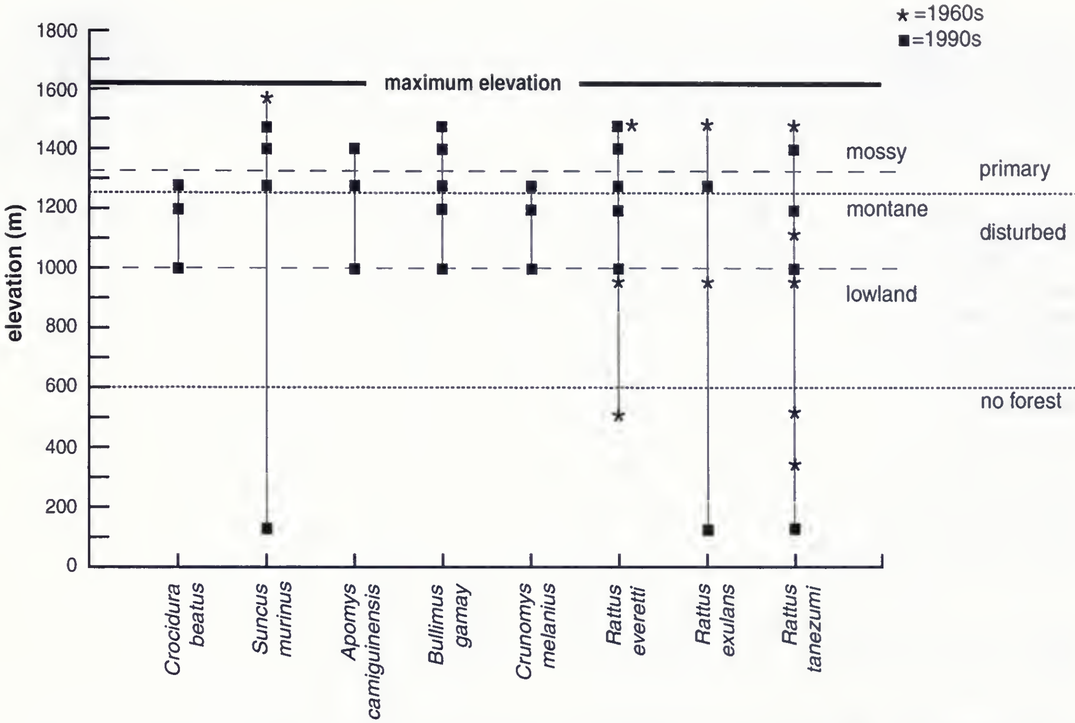

FIG. 1. Elevational range of nonvolant small mammals (Insectivora and Rodentia) on Camiguin Island, Philippines. Records from the 1960s are indicated with stars and from the 1990s by solid squares. The approximate original boundaries of primary lowland, montane, and mossy rain forest along the elevational gradient are indicated. The condition of forest along our transect in the middle 1990s is indicated as nearly absent (below 600 m), disturbed by logging and agriculture but present as second growth (about 600–1250 m), and primary or lightly disturbed by human activities and landslides (above about 1250 m). Elevations from the 1960s were rough estimates (see text).

1280 m (Heaney et al., 1989), which is similar to Sites 6 and 7.

Suncus murinus was most often trapped in runways or clear areas beneath fallen and rotting logs, under roots of trees, or under horizontal trunks of live trees as well as in runways near large boulders. Many were caught during daylight hours.

Five adult females with a mean weight of 32 ± 4.5 g (range = 27–39 g) were pregnant; litter sizes for four of these were one, two, three, and three. Thirteen nonpregnant parous females (those with large mammae) weighed an average of 28.8 ± 4.1 g (range = 22–35 g), and nulliparous females (those with small mammae) weighed 20.6 ± 2.2 g (range = 17.5–23 g, N = 10). Adult males (defined as those with large testes) had a mean weight of 36 ± 5.8 g (range 24–48 g, N = 27). Males are conspicuously larger than females in this species (Table 2).

SPECIMENS EXAMINED—Total 78. Site 3 (2 MSU-IIT); Site 6 (10 MSU-IIT); Site 7 (56 FMNH); Site 8 (9 FMNH); Site 15 (1 DMNH).

Order Chiroptera
Family Pteropodidae—Fruit Bats

Cynopterus brachyotis (Muller, 1838)

The common short-nosed fruit bat is widespread in Southeast Asia and is common throughout the Philippines. It ranges from sea level to at least 1250 m and is typically found in agricultural areas; it is also common in secondary lowland forest but usually rare in primary forest (Heaney et al., 1998).

Our limited netting on Camiguin during 1994–1995 (Table 3) indicated that *C. brachyotis* was abundant in a highly disturbed lowland agricultural area at 10 m elevation (Site 1) and was common in a heavily disturbed lowland agricultural area at 100 m (Site 2; Table 3). It was less

TABLE 1. Numbers of nonvolant small mammals captured in traps in heavily disturbed lowland agricultural area (Site 3), secondary lowland forest (Site 4), disturbed lower montane forest (Site 5), primary mossy forest (Site 6), primary montane forest (Site 7), and lower mossy forest (Site 8) on Camiguin Island. The numbers of captures per 100 trap-nights are given in parentheses. See Heaney and Tabaranza (2005a) for full site descriptions. Asterisks mark species presumed to be present; see Methods.

Scientific name	Site 3, 150 m	Site 4, 1000 m	Site 5, 1200 m	Site 6, 1300 m	Site 7, 1275 m	Site 8, 1475 m	Total
Crocidura beatus	0	3 (0.3)	1 (0.3)	0*	1 (0.2)	0	5
Suncus murinus	2 (1.4)	0*	0*	10 (2.9)	56 (8.5)	9 (2.3)	77
Apomys camiguinensis	0	14 (1.5)	0*	2 (0.6)	9 (1.4)	0	25
Bullimus gamay	0	4 (0.4)	2 (0.6)	3 (0.9)	10 (1.5)	1 (0.3)	20
Crunomys melanius	0	2 (0.2)	1 (0.3)	0*	2 (0.3)	0	5
Rattus everetti	0	7 (0.8)	2 (0.6)	3 (0.9)	2 (0.3)	2 (0.5)	16
Rattus exulans	2 (1.4)	0*	0*	0*	5 (0.8)	0	7
Rattus tanezumi	21 (14.2)	8 (0.9)	4 (1.2)	1 (0.3)	0	0	34
Total small mammals	24	38	10	19	85	12	188
Total trap-nights	148	907	339	348	655	386	2783
Number/100 trap-nights	16.2	4.2	2.9	5.5	9.9	3.1	6.8
Total small mammal species	3	6 (+1)	5 (+3)	5 (+3)	7	3	8
Native small mammal species	0	5	4 (+1)	3 (+2)	5	2	5

common in disturbed lowland forest at 1000 m (Site 4) and uncommon in disturbed lower montane forest at 1000–1300 m and mossy forest between 1200 and 1400 m elevation (Sites 5 and 6). Limited netting did not detect this species in montane primary forest at 1275 m elevation (Site 7). The occurrence of *C. brachyotis* in these habitats is consistent with records from other Philippine islands; for example, on Catanduanes, Leyte, Luzon, and Negros, this species was most abundant in agricultural land and secondary forest (Heaney et al., 1989, 1991, 1999; Heideman & Heaney, 1989; Ingle, 1992; Rickart et al., 1993), similar to Sites 1 and 3 to 5 on Camiguin. Records from the 1960s indicate that the species occurs along the entire elevational gradient, from sea level to near the peaks, although most specimens are from below 1000 m (i.e., below the transition to montane forest; Fig. 2).

Eight adult females (mean = 29.5 ± 4.72 g) taken in May 1992 and 1994 were pregnant with single embryos (CRL = 5–26 mm). Two of the pregnant females (22 and 35 g) and three non-pregnant ones (32.5–39 g) were lactating. Adult females with enlarged mammae but not pregnant or lactating had mean weight of 29.2 ± 2.3 g (range = 26–33.2 g, N = 13). Five nulliparous females had a mean weight of 16.5 g ± 2.0 g (range = 14–19 g). Males with abdominal testes had a mean weight of 27.4 ± 2.6 g (range = 22–32.5 g, N = 15). On Negros Island, this species probably produces two young per year, one in March/April and another in August/September (Heideman, 1995).

Females are slightly larger than males in most external and cranial dimensions (Table 4), a trend quite similar to specimens from Mt. Kitanglad, Mindanao (Heaney et al., unpubl. data). Specimens from Biliran, Leyte and Maripipi, in contrast, showed the opposite trend (Rickart et al., 1993).

SPECIMENS EXAMINED—Total 91. Site 1 (27 FMNH); Site 3 (5 MSU-IIT); Site 4 (4 FMNH, 14 MSU-IIT); Site 6 (1 FMNH, 3 MSU-IIT); Site 11 (12 DMNH); Site 12 (3 DMNH); Site 13 (6 DMNH); Site 16 (2 ROM); Site 17 (14 ROM).

Harpyionycteris whiteheadi Thomas, 1896

The harpy fruit bat has been reported previously from Camiguin (Peterson & Fenton, 1970), as well as from Marinduque, Masbate, Mindoro, Negros, southern Luzon, and throughout Greater Mindanao (Heaney et al., 1998, 1999). It is generally restricted to primary or lightly disturbed forest; it is usually rare in lowland forest but often is moderately common in montane forest from roughly 800 m to at least 1800 m. It apparently feeds heavily on the fruits of viney pandans (*Freycinetia* spp.) and figs (*Ficus* spp.); (Heaney et al., 1989, 1999; Heideman & Heaney, 1989; Rickart et al., 1993).

In May 1992, we netted one pregnant female weighing 123 g with a single embryo (CRL = 28 mm) at 10 m elevation, in a lowland

Table 2. Mean (±SD) and range of selected external and cranial measurements of adult shrews (Soricidae) from Camiguin Island, Philippines. Sample size smaller than N is indicated by the number enclosed in parentheses after the range. Measurements taken from sample sizes of 2 and 3 are given as averages and their ranges. All measurements except weight are in millimeters.

Species	Sex	N	Total length	Tail length	Hind foot	Weight (g)	Condylo-basal length	Braincase width	Interorbital breadth	Rostral length	I^1 to M^3	P^4 to M^3	M^2 to M^2 (labial)
Crocidura	M	1	127	58	14	7.0	19.6	9.5	4.7	8.2	8.9	5.0	6.4
beatus	F	2	128	58	14	6.0 (1)	20.3	9.4	4.7	8.7	9.2	5.2	6.2
			127–129	57–58	12–15		20.2–20.5	9.4–9.5	4.5–4.8	8.6–8.8	9.2	5.2	6.1–6.2
Suncus	M	9	184 ± 5.7	63 ± 3.5	20 ± 0.4	38 ± 3.6	28.0 0.62	12.2 ± 0.22	5.4 ± 0.19	11.8 ± 0.22	12.8 ± 0.20	6.9 ± 0.11	8.8 ± 0.14
murinus			177–192 (8)	58–69 (8)	20–21	30–42	26.7–28.6	11.7–12.5	5.2–5.8	11.4–12.1	12.6–13.1	6.7–7.0	8.6–9.0
	F	3	177	58	18	23	26.2	11.4	5.2	11.0	12.0	6.4	8.4
			174–182	54–58	18–19	26–33	24.8–26.6	11.1–11.6	5.1–5.2	10.6–11.2	11.6–12.4	6.2–6.6	8.1–8.6

agricultural area (Site 1; Table 3). On Mindanao (Kitanglad Range), pregnant females were similarly recorded in May, with further records of pregnancy in April, August, and October; lactation was noted in March, April, and August (Heaney et al., unpubl. data). In March 1995, at Site 7 (1275 m in primary montane forest), where *Freycinetia* spp. were abundant, we often heard the distinctive *Harpyionycteris* whistles (Rickart et al., 1993; Heaney et al., 1999), but none were captured. Combined with records from the 1960s (Fig. 2), these data indicate that it occurs on this island from sea level to 1500 m in lowland, montane, and mossy forest.

External and cranial measurements of *H. whiteheadi* on Camiguin are comparable to those from Mindanao (Mt. Kitanglad) but are slightly larger than those found on Leyte and Luzon (Mt. Isarog) (Heaney, 1984; Rickart et al., 1993; Heaney et al., 1999, unpubl. data).

Specimens Examined—Total 4. Site 1 (1 fmnh); Site 11 (1 dmnh); Site 12 (1 dmnh); Site 16 (1 rom).

Macroglossus minimus (E. Geoffroy, 1810)

The dagger-toothed flower bat occurs from Thailand to Australia and is found throughout the Philippines (Heaney et al., 1998). Within the Philippines, it occurs in virtually every habitat in the country, from sea level to at least 2250 m. It is often abundant in agricultural and heavily disturbed areas, is common in secondary forest, and usually is uncommon in primary forest. It is most often associated with domestic or wild banana (*Musa* spp.; Heaney et al., 1989, 1999; Heideman & Heaney, 1989; Rickart et al., 1993).

On Camiguin, our limited netting showed *M. minimus* to be abundant in a highly disturbed lowland agricultural area at ca. 10 m elevation (Site 1), present in a heavily disturbed lowland agricultural area at 100 m (Site 3), uncommon in disturbed lowland forest at 1000 m (Site 4), common in disturbed lower montane forest at 1000–1300 m (Site 5), and present in mossy forest between 1200 and 1400 m elevation (Site 6; Table 3). Limited netting did not detect this species in primary montane forest at 1275 m elevation (Site 7). Combined with prior records, it is apparent that this species occurs on Camiguin from sea level to at least 1200 m, in lowland and montane forest, in both disturbed and undisturbed forest (Fig. 2).

TABLE 3. Numbers of fruit bats captured in mist nets in a lowland agricultural area (Site 1), heavily disturbed lowland agricultural area (Site 3), secondary lowland forest (Site 4), disturbed lower montane forest and primary mossy forest (Sites 5 and 6 concurrently), and primary montane forest (Site 7) on Camiguin Island during 1992, 1994, and 1995. The number of captures per net-night are given in parentheses. See Heaney and Tabaranza (2006a) for full site descriptions. Asterisks indicated species observed but not netted (see text).

Scientific name	Site 1, 10 m	Site 3, 150 m	Site 4, 1000 m	Sites 5 and 6, 1200–1400 m	Site 7, 1275 m
Cynopterus brachyotis	27 (4.5)	5 (1.67)	18 (0.75)	4 (0.29)	0
Harpyionycteris whiteheadi	1 (0.17)	0	0	0	0*
Macroglossus minimus	15 (2.5)	1 (0.33)	4 (0.17)	9 (0.64)	0
Ptenochirus jagori	8 (1.33)	0	16 (0.67)	1 (0.07)	0
Total fruit bats	51	5	35	14	0
Total net-nights	6	3	24	14	8
Fruit bats per net-night	8.5	1.67	1.46	1.00	0

Six adult females netted in May 1992 and 1994, with a mean weight of 15.2 ± 3.2 g (range = 12.5–20.3 g), were pregnant with single embryos. Four parous females with large mammae but neither pregnant nor lactating had a mean weight of 18.5 ± 1.78 g (range = 16–20 g). Three adult males weighed between 16 and 19 g. A juvenile male and a juvenile female each weighed 5 g. On Mindanao (Kitanglad Range), pregnant females were recorded in April to August and October, while lactating females were recorded in May, September, and October (Heaney et al., unpubl. data). Heideman (1995) documented that this species undergoes aseasonal breeding and postpartum estrus on Negros Island and has several young per year.

Comparison with specimens of *M. minimus* from Biliran, Dinagat, Leyte, Luzon (Mt. Isarog), Maripipi, and Mindanao (Kitanglad Range) shows that while the overall variation

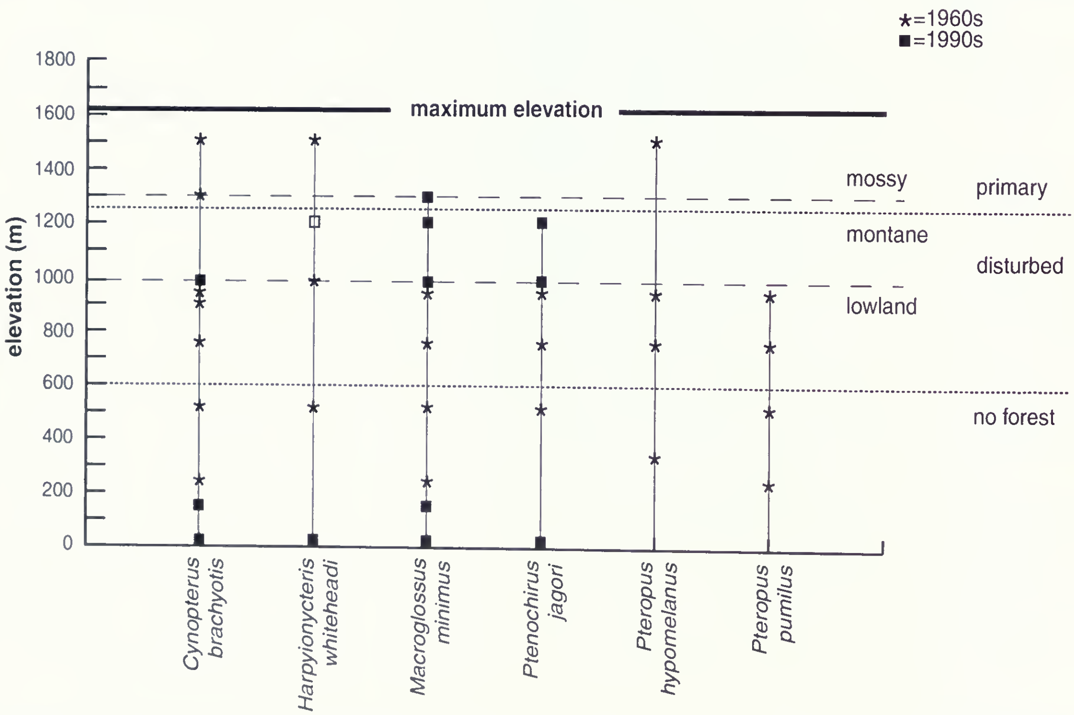

FIG. 2. Elevational range of fruit bats (Pteropodidae); symbols and boundaries as in Figure 1. The open square indicates a documented record without a voucher specimen (see text).

TABLE 4. Mean (±SD) and range of selected external and cranial measurements of adult fruit bats (Pteropodidae) from Camiguin Island, Philippines. Sample size smaller than N is indicated by the number enclosed in parentheses after the range. Measurements taken from sample sizes of 2 and 3 are given as averages and their ranges. All measurements except weight are in millimeters.

Species	Sex	N	Total length	Tail length	Hind foot	Ear	Forearm	Weight (g)	Condylo-basal length	Zygomatic breadth	Inter-orbital width	Mastoid breadth	Rostral length	C^1 to last M	Molariform toothrow
Cynopterus	M	8	90 ± 5.1	9 ± 1.9	13 ± 1.1	16 ± 1.4	62 ± 2.5	27 ± 2.4	27.4 ± 0.52	18.1 ± 0.26	6.0 ± 0.32	11.5 ± 0.25	8.6 ± 0.42	9.3 ± 0.28	6.5 ± 0.19
brachyotis			83–96	6–12	12–15 (6)	13–17	58–65	22–28	26.6–28.2	17.6–18.5	5.4–6.2	11.3–12.0	7.7–9.2	9.0–9.6	6.3–6.8
	F	10	96 ± 1.6	8 ± 2.2	—	17 ± 0.8	65 ± 2.1	29 ± 1.7	27.0 ± 0.76	18.2 ± 0.68	6.0 ± 0.22	11.6 ± 0.36	8.6 ± 0.52	9.1 ± 0.38	6.4 ± 0.27
			94–98	4–12 (9)		16–18	62–69	27–32	26.1–28.1	17.1–19.1	5.6–6.4	10.9–12.1	8.0–9.8 (9)	8.5–9.7	6.0–6.8
Harpyionycteris	M	1	145	0	25	22	84	—	40.5	24.3	6.9	15.3	—	15.7	11.8
*whiteheadi**	F	2	157	0	26	20	86	123	41.9	25.1	6.8	15.8	11.8	16.2	12.4
			155–159		26 (1)	17–23	84–88	123 (1)	41.5–42.4	25.1	6.7–6.9	15.8–15.9	11.7–11.9	16.1–16.4	12.3–12.5
Macrogolossus	M	6	74 ± 1.5	—	12	16 ± 1.0	43 ± 1.2	17 ± 2.9	25.2 ± 0.72	15.4 ± 0.38	5.0 ± 0.42	10.3 ± 0.49	10.0 ± 0.37	8.9 ± 0.34	5.6 ± 0.28
minimus			72–76		10–14 (3)	14–17	42–45	12–20	24.6–26.2	14.9–15.8 (4)	4.5–5.7	9.8–10.8	9.3–10.3	8.5–9.4	5.1–5.9
	F	4	75 ± 2.6	—	12	16 ± 0.5	44 ± 1.3	16 ± 3.8	25.5 ± 0.79	13.9 ± 0.23	4.7 ± 0.23	10.2 ± 0.13	9.7	9.0 ± 0.42	5.5 ± 0.12
			73–78		12 (2)	15–16	42–45	12–20	24.4–26.2	13.6–14.1	4.4–5.0	10.0–10.3	9.6–10.0 (3)	8.5–9.4	5.3–5.6
Ptenochirus	M	10	117 ± 8.6	13 ± 1.4	19 ± 1.7	21 ± 1.7	85 ± 3.1	75 ± 3.0	35.1 ± 0.58	24.6 ± 0.49	7.3 ± 0.28	14.7 ± 0.34	10.9 ± 0.42	12.5 ± 0.26	8.8 ± 0.29
jagori			105–128	11–15	16–21 (7)	18–24	80–89	70–78	34.0–36.2	23.8–25.6	6.8–7.7	14.3–15.4	10.2–11.8	12.1–12.9	8.5–9.3
	F	8	124 ± 7.0	12 ± 1.8	19	20 ± 1.2	82 ± 1.3	71 ± 4.5	34.8 ± 0.65	24.0 ± 0.64	7.1 ± 0.28	14.6 ± 0.33	10.4 ± 0.27	12.0 ± 0.32	8.4 ± 0.28
			113–131	9–14	17–20 (3)	19–22	80–83	63–75	33.8–35.9	23.0–25.1	6.8–7.6	14.2–15.0	10.0–10.8	11.5–12.6	8.0–8.9
Petropus	M	3	228	0	42	28	141	—	61.3	35.2	8.8	20.2	22.7	23.4	16.4
*hypomelanus**			219–239		40–45	26–29	139–142 (2)		61.3 (1)	32.2–37.5	8.3–9.2	20.1–20.4 (2)	22.3–23.3	22.8–24.0	16.2–16.5
	F	2	211	0	38	30	134	—	61.0	34.8	9.1	19.6	22.2	23.6	16.1
			200–222		34–43	30–31	131–138		59.7–62.3	33.9–35.6	8.6–9.5	19.2–20.1	21.7–22.6	23.4–23.7	16.1
Pteropus	M	4	168 ± 12.5	0	35 ± 2.5	22 ± 2.2	106 ± 2.2	—	49.2 ± 1.39	27.9 ± 0.47	7.3 ± 0.61	17.6 ± 0.36	16.8 ± 0.54	18.0 ± 0.39	12.6 ± 0.10
*pumilus**			151–179		32–38	19–24	102–107		48.3–51.3	27.6–28.6	6.8–8.2	17.1–17.9	16.1–17.3	17.6–18.4	12.5–12.7
	F	3	178	0	34	21	105	—	48.6	27.5	6.9	17.2	17.0	17.5	12.2
			168–189		32–34	17–24	103–108		47.5–49.7	27.4–27.6 (2)	6.8–7.5	17.0–17.3 (2)	16.0–17.6	17.1–17.7	11.9–12.5

* Includes measurements from Heaney (1984).

in cranial and external measurements is slight, Camiguin specimens tend to cluster consistently within the upper ranges of most features measured (Table 4; Heaney and Rabor, 1982; Heaney et al., 1991, 1999, unpubl. data; Rickart et al., 1993).

Specimens Examined—Total 56. Site 1 (15 FMNH); Site 3 (1 MSU-IIT); Site 4 (4 MSU-IIT); Site 5 (8 MSU-IIT); Site 6 (1 MSU-IIT); Site 11 (12 DMNH); Site 13 (5 DMNH); Site 14 (2 DMNH); Site 17 (8 DMNH).

Ptenochirus jagori (Peters, 1861)

The musky fruit bat is a common Philippine endemic, occurring throughout the archipelago with the exception of the Batanes/Babuyan and Palawan faunal regions from sea level to at least 1800 m (Heaney et al., 1998). Our limited netting on Camiguin showed *Ptenochirus jagori* to be common in a lowland agricultural area at 10 m elevation (Site 1), less common in disturbed lowland forest at 1000 m (Site 4), and scarce in primary mossy forest at 1300 m (Site 6; Table 3). Combined with records from the 1960s, these data indicate that the species is widespread in lowland and montane rain forest from sea level to at least 1200 m (Fig. 2), though probably its abundance declines with increasing elevation and with increasing levels of disturbance (Table 3), as noted elsewhere (Heaney et al., 1989, 1999, unpubl. data; Heideman & Heaney, 1989; Rickart et al., 1993; Lepiten, 1997).

Three adult females, netted in May 1992 and 1994, weighing an average of 70 g (range = 68–75 g), were pregnant with a single embryo each (CRL = 5–10 mm). Three nonpregnant females with large mammae had an average weight of 73.5 g (range = 72–74 g), and two nulliparous females weighed 67 and 68.5 g. Eleven adult males had a mean weight of 73.2 ± 4.7 g (range = 64–78 g, N = 11). Pregnant females of *P. jagori* have been recorded also in May on Luzon (Mt. Isarog) (Heaney et al., 1999). On Mindanao (Kitanglad Range), pregnant females were recorded in March, May, July, and August and lactating females in May to June and August to December (Heaney et al., unpubl. data). Heideman and Powell (1998) found that on Negros Island, *P. jagori* gives birth to a single young twice each year: the first in late March or early April and the second in August. It was further discovered that this species undergoes delayed implantation and early development that lasts for five months, shorter than in two other endemic species of Philippine pygmy fruit bats, *Haplonycteris fischeri* and *Otopteropus cartilagonodus*, where the phenomenon was first detected (Heideman, 1989; Heideman et al., 1993; Heideman & Powell, 1998). Additionally, this condition was apparently exhibited by primiparous young adult females only, allowing them to give birth only once in their first year, which had the effect of enabling them to synchronize breeding with the adult females the following year (Heideman & Powell, 1998).

Males are somewhat larger than females in most cranial and external dimensions, as on Biliran, Leyte, and Maripipi (Table 4; Rickart et al., 1993). Cranial and external measurements (Table 4) are noticeably larger than those for series from Catanduanes and southern Luzon and were similar to those from Biliran, Leyte, and Maripipi (Heaney, 1984; Heaney et al., 1991, 1999; Rickart et al., 1993).

Specimens Examined—Total 46. Site 1 (8 FMNH); Site 4 (16 MSU-IIT); Site 6 (1 MSU-IIT); Site 11 (6 DMNH); Site 13 (6 DMNH); Site 17 (9 ROM).

Pteropus hypomelanus Mearns, 1905

The common island flying fox occurs from Thailand to Australia and is found throughout the Philippines with the exception of the Palawan faunal region. It is often common in agricultural areas from sea level to ca. 900 m and is absent in primary forest (Heideman & Heaney, 1989; Heaney et al., 1991, 1998; Utzurrum, 1992; Rickart et al., 1993). Records from the 1960s document it from Camiguin at elevations from about 250 to 1500 m (Fig. 2), but we netted none in the 1990s; because this species typically flies above the canopy and our nets were set not more than about 4 m above the ground, our failure to catch any does not necessarily indicate any change in their abundance.

External and cranial measurements show only slight variations with those of specimens from Dinagat, Panay, Leyte, and Maripipi (Heaney & Rabor, 1982; Rickart et al., 1993).

Specimens Examined—Total 8. Site 10 (2 DMNH); Site 12 (1 DMNH); Site 13 (2 DMNH); Site 17 (3 ROM).

Pteropus pumilus Miller, 1910

The little golden-mantled flying fox is endemic to the Philippines (aside from a single population on Miangas Island, Indonesia, adjacent to Mindanao) and occurs throughout the archipelago, with the exception of the Batanes/Babuyan

and Palawan regions (Heaney et al., 1998). Previously reported from Camiguin as *P. tablasi*, the species was revised to include *P. tablasi* and *P. balutus* as synonyms under *Pteropus pumilus* (Klingener & Creighton, 1984). It is associated with primary and good secondary lowland forest from sea level to about 1100 m, and it is uncommon outside of forest. Additionally, it is most common on small islands and is uncommon to rare on larger islands. *Pteropus pumilus* often is netted in clearings or on ridgetops (Heideman & Heaney, 1989; Utzurrum, 1992; Rickart et al., 1993).

We did not encounter *P. pumilus* during the 1990s, but the 1967–1969 surveys obtained 42 individuals at four sites from ca. 250 to nearly 1000 m elevation (Fig. 2). As with *Pteropus hypomelanus*, this species usually flies above the canopy, so our failure to catch any in the 1990s does not necessarily indicate a change in their status on the island.

Specimens Examined—Total 42. Site 11 (19 DMNH); Site 13 (2 DMNH); Site 14 (1 DMNH); Site 17 (20 ROM).

Family Emballonuridae—Sheath-tailed Bats

Emballanura alecto (Eydoux and Gervais, 1836)

The Philippine sheath-tailed bat is a common cave-dwelling species that occurs throughout most of the Philippines and is also known from Borneo, the Moluccas, and Sulawesi (Koopman, 1989). It has been recorded only in lowland areas (450 m and below) in disturbed forest and agricultural areas with scattered remnant forest, with most captures recorded from caves, under large boulders, or in man-made tunnels (Heaney et al., 1991, 1999; Rickart et al., 1993). We did not record this species during our fieldwork in 1994 and 1995, but in 1967 specimens were taken from Tag-ibo Cave at 400 ft (ca. 120 m) and at 1400–3300 ft (ca. 400–1000 m) on Mt. Mambajao (see also Heaney, 1984).

Comparison of external and cranial measurements with series from Leyte and Biliran shows little variation (Table 4; Rickart et al., 1993).

Specimens Examined—Total 4. Site 17 (2 ROM); Site 18 (2 ROM).

Family Rhinolophidae—Horseshoe-nosed Bats

Rhinolophus arcuatus Peters, 1871

The arcuate horseshoe bat is widespread from Sumatra to New Guinea and throughout the Philippines (Heaney et al., 1998), including the Palawan faunal region (Esselstyn et al., 2004). It is most often encountered from lowlands to at least 1350 m in agricultural lands to primary lowland and montane forest and occasionally roosts in caves (Heaney et al., 1991, 1999; Rickart et al., 1993). Two groups that differ in size and habitat are recognized within this species: a smaller morphotype, designated *R. arcuatus*—s, that occurs in the lowlands or disturbed habitats, and a larger one, designated *R. arcuatus*—l, found in forest at higher elevations (Ingle & Heaney, 1992).

In May 1994, we netted this species at 1000 m elevation in disturbed lowland forest (Site 4). Of two adult females netted, one (15 g) was pregnant with one large embryo (CRL = 28 mm), and the other was lactating (12.5 g). Pregnancies in this species were recorded also in March on Luzon (Mt. Isarog) and in April on Biliran, Leyte, and Maripipi (Rickart et al., 1993; Heaney et al., 1999).

Cranial and external measurements (Table 5) of the Camiguin specimens are consistently larger than those in series from Biliran, Leyte, Luzon (Mt. Makiling), Maripipi, and Mindanao (Mt. Kitanglad), which all fall within the dimensions of the smaller morphotype, *R. arcuatus*—s (Ingle & Heaney, 1992; Rickart et al., 1993; Heaney et al., 1999, unpubl. data). Instead, their external and cranial dimensions are comparable to the larger morphotype, *R. arcuatus*—l (Ingle & Heaney, 1992). Systematics in this "species" are badly in need of detailed study.

Specimens Examined—Total 10. Site 4 (4 MSU-IIT); Site 13 (6 DMNH).

Rhinolophus inops K. Anderson, 1905

The Philippine forest horseshoe bat is common to abundant in primary lowland and montane forest from sea level to 2250 m and is usually rare in secondary forest and mossy forest (Heaney et al., 1991, 1998, 1999; Rickart et al., 1993). Improvements in our understanding of Philippine *Rhinolophus* lead us to reidentify the single specimen from Site 13, reported as *R. subrufus* by Heaney (1984), as *R. inops*. We netted two additional males in disturbed lowland forest at 1000 m (Site 4). Cranial and external measurements (Table 5) are slightly larger in most dimensions than those of the series from Biliran, Leyte (Rickart et al., 1993), and Mindanao (Mt. Kitanglad; Heaney et al., unpubl. data); we suspect that regional morphs corresponding to the Pleistocene islands (Heaney, 1986) are present.

Table 5. Mean (±SD) and range of selected external and cranial measurements of adult microbats (Emballonuridae, Rhinolophidae, and Vespertilionidae) from Camiguin Island, Philippines. Sample size smaller than N is indicated by the number enclosed in parentheses after the range. Measurements taken from sample sizes of 2 and 3 are given as averages and their ranges. All measurements except weight are in millimeters.

Species	Sex	N	Total length	Tail length	Hind foot	Ear	Forearm	Weight (g)	Condylo-basal length	Zygomatic breadth	Inter-orbital width	Mastoid breadth	Rostral length	C^1 to last M	Molariform toothrow
*Emballonura alecto**	F	2	6.2	11	8	15	44	—	13.8	8.7	2.8	—	—	5.5	4.0
			6.2	11	8	15	44 (1)		13.6–13.9	8.5–8.9	2.7–2.9			5.3–5.6	3.9–4.0
*Rhinolophus arcuatus**	M	6	74 ± 4.5	18 ± 1.7	11 ± 0.4	21 ± 0.4	43 ± 3.2	—	19.8 ± 0.43	10.1 ± 0.24	1.8 ± 0.19	10.0 ± 0.17	8.5 ± 0.27	7.8 ± 0.17	5.6 ± 0.06
			71–83	16–21	11–12	20–21	40–48 (5)		19.3–20.4 (5)	9.8–10.5	1.4–1.9	9.8–10.2	8.2–8.8	7.5–7.9	5.5–5.7
*Rhinolophus inops**	M	1	87	22	12	21	51	—	23.2	12.1	2.1	11.2	10.4	9.3	6.8
Rhinolophus virgo	F	1	69	24	9	18	39	—	15.7	8.2	2.0	8.2	6.6	5.9	4.6
Pipistrellus javanicus	M	1	82	34	9	11	34	—	13.1	8.8	3.6	7.5		4.7	3.7
	F	1	—	—	—	—	—	—	13.1	9.1	3.7	8.1	—	4.8	3.8

* Includes measurements from Heaney (1984).

Specimens Examined—Total 3. Site 4 (2 msu-iit); Site 13 (1 dmnh).

Rhinolophus virgo K. Anderson, 1905

The yellow-faced horseshoe bat is an endemic species widespread within the Philippines. It is usually encountered in primary lowland forest from 250 to 1100 m; several records are from caves (Heaney et al., 1991; Rickart et al., 1993). We obtained one adult female from the edge of a small tree-fall gap in primary montane forest at 1275 m on 22 March 1995 (Site 7). It has small mammae and showed no indication of reproductive activity. Cranial dimensions (Table 5) fall within the range of those from Leyte and Maripipi but are slightly smaller than those from Mindanao (Mt. Kitanglad; Rickart et al., 1993; Heaney et al., unpubl. data).

Specimens Examined—Total 1. Site 7 (1 fmnh).

Family Vespertilionidae—Common Bats

Murina cyclotis Dobson, 1872

The round-eared tube-nosed bat is widespread in southern Asia and was previously known in the Philippines from a few specimens from the central and southern portion of Greater Luzon as well as Greater Mindanao, Sibuyan, and Siquijor, with records from disturbed and primary lowland and montane forest from 250 to 1500 m (Heaney et al., 1991, 1998, 1999, unpubl. data; Rickart et al., 1993; Ruedas, 1994; Lepiten, 1997). We netted one adult female in May 1994 in secondary lowland forest at 1000 m (Site 4).

Specimens Examined—Total 1. Site 4 (1 msu-iit).

Pipistrellus javanicus (Gray, 1838)

The Javan pipistrelle is found from Korea to Java and throughout the Philippines. It is generally common in primary montane forest and uncommon in primary lowland and mossy forest, though it has been found from sea level to 2250 m (Ingle, 1992; Heaney et al., 1998, 1999, unpubl. data). A single skin without a skull, tentatively identified as this species, was obtained from Camiguin by the 1960s surveys. In March 1995, two were netted in primary montane forest at 1275 m (Site 7). Cranial and external measurements (Table 5) are comparable with those of a series from Mindanao (Mt. Kitanglad) in most dimensions (Heaney et al., unpubl. data).

Specimens Examined—Total 3. Site 7 (2 fmnh); Site 13 (1 dmnh).

Order Primates
Family Cercopithecidae—Monkeys
Macaca fascicularis (Raffles, 1821)

The long-tailed macaque occurs from Burma to Timor and is found throughout the Philippines (Fooden, 1995; Heaney et al., 1998). It is found in agricultural areas near forest, in second-growth and secondary forest, as well as primary forest from sea level to at least 1800 m in lowland and montane forest (Goodman & Ingle, 1993; Rickart et al., 1993; Heaney et al., 1999). We did not collect any specimens, but in March 1995 we obtained the skull of an adult individual from a hunter who had killed the macaque in a forested area above Mahinog a few years earlier. Also in March 1995, a local hunter who was a member of our team saw two macaques a short distance from our camp at 1100 m elevation (Site 7) in primary montane forest. He reported that the macaques were fairly common in what remained of lowland primary forest and good secondary forest at that time and were actively hunted.

Specimens Examined—Total 1. Above Mahinog (1 fmnh).

Order Rodentia
Family Muridae—Rats and Mice
Apomys camiguinensis Heaney and Tabaranza, 2006

A previously unknown species of *Apomys* (Musser, 1982) was trapped on Camiguin in May 1994 and March 1995 (Heaney & Tabaranza, 1997) and described in this volume (Heaney & Tabaranza, 2006b). The Camiguin forest mouse is moderately large for the genus, averaging about 40 g. It is marked by a number of subtle morphological characters, and molecular data show it to be most closely related to *Apomys hylocoetes* and *A. insignis* from Mindanao and to an unnamed species from Leyte and Biliran (Steppan et al., 2003; Heaney & Tabaranza, 2005b). This species was common (Table 1, Fig. 1) in disturbed lowland forest at 1000 m (Site 4) and in primary montane forest at 1275 m (Site 7) and relatively uncommon in primary mossy forest at 1200–1400 m (Site 6). It was not found in heavily disturbed lowland agricultural land (Site 3, elev. 150 m), lower montane forest (Site 4, elev. 1000–1300 m), or lower mossy forest (Site 8, elev. 1475 m), but there was limited sampling at all of these (Table 1). Most specimens were taken from traps placed in primary montane forest underneath root tangles and beneath fallen and rotten logs on a moderate slope. All individuals were captured at night.

A pregnant female taken on 29 May 1994 weighed 40.5 g and had a single embryo (CRL = 30 mm). Adult females with large mammae but not pregnant weighed 39 ± 2.1 g (range = 37.5–42 g, N = 5); two of these, taken 23 May 1994 and 17 March 1995, each had two placental scars. Nulliparous females (with small mammae) were lighter and had an average weight of 35 g (range = 34–36). Females have two pair of inguinal mammae. These data indicate a litter size between one and two. Males with scrotal testes had a mean weight of 41.3 ± 4.7 g (range = 36.5–48 g, N = 11); testis size ranged from 15 × 16 mm to 8 × 12 mm. Males with abdominal testes weighed 33.0 ± 5.0 g (range = 28–34 g, N = 5) and had testis size of 5 × 8 mm.

Specimens Examined—Total 25. Site 4 (14 msu-iit), Site 6 (2 msu-iit); Site 7 (9 fmnh).

Bullimus gamay Rickart, Heaney and Tabaranza, 2002

A previously unknown species of *Bullimus*, recently described as *B. gamay* (Rickart et al., 2002), was captured on Camiguin in May 1994 and March 1995. The Camiguin forest rat was incorrectly assigned to *Tarsomys* by Heaney and Tabaranza (1997) and was designated "*Bullimus* sp. A" by Heaney et al. (1998). It was trapped from 900 to 1475 m (Fig. 1, Table 1) but not in heavily disturbed lowland agricultural land from sea level to 300 m (Site 3). Most specimens were taken from traps placed in runways beneath root tangles and rotten logs or near large rocks. This species was most common in primary montane forest at 1275 m (Site 7). It was less common in disturbed lower montane forest at 1000–1300 m (Site 5) and in primary mossy forest at 1200–1400 m (Site 6). It was rare in secondary lowland forest at 1000 m (Site 4) and in lower mossy forest at 1475 m (Site 8). *Bullimus bagobus* occurs in similar habitat on Mindanao but also occurs at lower elevation where good forest persists (Heaney, 2001; Heaney et al., unpubl. data); this suggest that *B. gamay* should also be sought at lower elevations on Camiguin.

Parous females with large mammae weighed an average of 370 g (range = 360–390 g, N = 3), while nulliparous young adult females with small

mammae were lighter, having a mean weight of 276 ± 53.7 g (range = 210–345 g, N = 5). Adult males with scrotal testes had an average weight of 402 g (range = 240–500 g; N = 3) and had testis size ranging from 21 × 30 mm to 27 × 35 mm). Among the nine individuals taken in May 1994, the smallest was a nulliparous young female weighing 210 g, while among the 11 individuals captured in March 1995, two were juveniles, a male weighing 120 g and a female weighing 125 g. No pregnant females were taken in May 1994 and March 1995, but a lactating female (360 g) was taken on 18 March 1995, and a female taken on 29 May 1994 had three placental scars. This suggests that females give birth in February and March. Three females had three pairs of mammae and one had four pairs, indicating that litter size most likely does not exceed three.

SPECIMENS EXAMINED—Total 20. Site 4 (4 MSU-IIT); Site 5 (2 MSU-IIT); Site 6 (3 MSU-IIT); Site 7 (10 FMNH); Site 8 (1 FMNH).

Crunomys melanius Thomas, 1907

The Mindanao shrew-mouse was previously known only from Leyte and Mindanao from near sea level to 1550 m, apparently in primary lowland rain forest; it is rare in collections (Musser & Heaney, 1992; Heaney et al., 1998; unpubl. data; Rickart et al., 1998). On Camiguin, we found it to be uncommon in heavily disturbed lowland agricultural land at 1000 m (Site 4), in disturbed lower montane forest at 1200 m (Site 5), and in primary montane forest at 1275 m (Site 7; Table 1, Fig. 1). It was trapped beneath rotten logs and wood tangles in an area with few dead leaves and little moss. It occurs down to sea level in good forest on Mindanao (Heaney et al., 1998; Heaney, 2001) and should also be sought at lower elevations on Camiguin.

Two of the five specimens we captured were females. An adult female taken on 17 March 1995, with enlarged mammae and weighing 71 g, had recently given birth; it had three placental scars (one left, two right), and the uterus was swollen. The other female (62.5 g), probably nulliparous, had small mammae. Two adult males (60 g and 72 g) had scrotal testes (15 × 8 mm); the third male, taken on 24 May 1994, was a small juvenile (28 g) with abdominal testes. These scanty data imply that March, April, and May are months of reproductive activity. Females have two pairs of mammae, indicating that litter size is small.

Cranial and external measurements (Table 6) are similar to but slightly larger than those from Leyte and Mindanao (Kitanglad Range and Mt. Apo; Rickart et al., 1993, 1998; Heaney et al., unpubl. data).

SPECIMENS EXAMINED—Total 5. Site 4 (2 MSU-IIT); Site 5 (1 MSU-IIT); Site 7 (2 FMNH).

Rattus everetti (Gunther, 1879)

The common Philippine forest rat is a widespread endemic species (excluding the Babuyan/Batanes, Palawan, and Sulu groups) found in primary and disturbed lowland, montane, and mossy forest from sea level to 2400 m (Heaney et al., 1991, 1998, 1999; Musser & Heaney, 1992; Rickart et al., 1993).

During 1994–1995, we found this 250–350 g rodent to be fairly common at all sampling sites from disturbed lowland forest at 1000 m, through montane forest to mossy forest at 1475 m; specimens from the 1960s were taken at 500 m (Table 1, Fig. 1); on Mindanao, it occurs down to sea level (Heaney, 2001; Heaney et al., unpubl. data). It was trapped under root tangles and beneath fallen logs, in hollow spaces beneath live trees, and near mounds of soil and rotting leaves.

Five parous adult females from May 1994 and March 1995 had a mean weight of 271 ± 28.8 (range = 240–300 g, N = 5). During the same months, five nulliparous females (with adult pelage) weighed 188 ± 21.4 g (range = 160–215 g), and four females with juvenile pelage weighed 116 ± 31.0 g (range = 77–150 g). Females have four pairs of mammae, indicating moderate litter size. None were pregnant, and we were unable to count placental scars; previous studies also produced little data on litter size (Heaney et al., 1999, unpubl. data). Males with scrotal testes, recorded in May 1994 and March 1995, had a mean weight of 288 ± 69.8 g (range = 210–375 g, N = 4), and the largest males had testes size of 33 × 52 mm and 30 × 50 mm. Three males with abdominal testes, during the same months, weighed an average of 207 g (range = 160–295 g).

Cranial and external measurements (Table 6) are comparable to those from Biliran, Leyte, and Maripipi but slightly smaller than series from Dinagat, Mindanao (Kitanglad Range), and Siargao (Heaney & Rabor, 1982; Heaney et al., 1991, 1999, unpubl.; Rickart et al., 1993).

SPECIMENS EXAMINED—Total 28. Site 4 (6 MSU-IIT); Site 5 (2 MSU-IIT); Site 6 (3 MSU-IIT); Site 7 (8

Table 6. Mean (±SD) and range of selected external and cranial measurements of adult murid rodents (Muridae) from Camiguin Island, Philippines. Sample size smaller than N is indicated by the number enclosed in parentheses after the range. Measurements taken from sample sizes of 2 and 3 are given as averages and their ranges. All measurements except weight are in millimeters.

Species	Sex	N	Total length	Tail length	Hind foot	Ear	Weight (g)	Basi-occipital length	Inter-orbital width	Zygomatic breadth	Mastoid breadth	Nasal length	Maxillary molari-fom toothrow	Diastema
Apomys camiguensis	M	6	260 ± 4.4	148 ± 7.4	33 ± 1.0	19 ± 0.8	41.1 ± 5.39	29.2 ± 0.48	5.2 ± 0.12	14.9 ± 0.29	12.9 ± 0.20	11.1 ± 0.50	6.0 ± 0.20	7.3 ± 0.26
			254–266	140–160	31–34	17–19	39–48.5	28.6–29.8	5.1–5.4	14.6–15.3 (5)	12.6–13.1 (5)	10.5–11.8	5.8–6.3	6.8–7.5
	F	4	254 ± 6.6	146 ± 4.8	32 ± 1.3	18 ± 2.2	38.5 ± 3.54	28.3	5.2 ± 0.22	14.8 ± 0.43	12.6	11.0 ± 0.58	6.0 ± 0.14	7.1 ± 0.27
			246–262	140–150	31–34	15–20	34–42	27.9–28.7 (3)	4.9–5.4	14.3–15.3	12.2–12.8 (3)	10.3–11.7	5.9–6.2	6.8–7.4
Bullimus gamay	M	1	398	175	54	26	305	47.5	8.2	25.7	19.6	20.3	9.1	13.4
	F	5	372 (3)	154 (3)	49 (3)	25 (3)	334 (3)	48.2 ± 0.81	7.9 ± 0.33	25.8 ± 0.46	18.9 ± 0.60	20.4 ± 0.91	9.0 ± 0.20	14.3 ± 0.69
			358–385	124–180	45–51	23–27	295–360	47.4–49.0	7.4–8.2	25.3–26.3	18.4–19.8	19.4–21.5	8.7–9.1	13.7–15.3
Crunomys melanius	M	1	185	81	24	15	28	31.3	6.3	14.8	12.7	13	4	8.8
Rattus everetti	M	2	462	246	46	24	255	47.5	6.5	24.7	18.6	19.3	9.5	13.1
			456–468	245–248	44–47	24–25	255 (1)	46.8–48.3	6.3–6.7	24.7–24.8	18.7–18.8	19.3 (1)	9.2–9.8	12.8–13.4
	F	5	443	434	46 ± 1.9	23 ± 0.9	238	47.1 ± 1.95	7.0 ± 0.20	25.4 ± 1.05	18.7 ± 0.39	18.8 ± 1.79	9.3 ± 0.34	13.5 ± 1.05
			388–456 (3)	224–252 (3)	44–49	22–24	190–285	45.5–49.9	6.8–7.4	24.3–26.7	18.3–19.2	17.3–21.9	9.0–9.8	12.6–14.9
							(3)	(4)		(4)	(4)			
Rattus exulans	M	5	263	130	27 ± 0.4	18 ± 1.3	69	31.3 ± 0.99	5.1 ± 0.12	16.3	13.6 ± 0.49	11.8 ± 0.52	5.5 ± 0.15	8.6 ± 0.61
			250–277	118–144	26–27	17–20	61–76	29.8–31.8	5.0–5.3	15.7–17.0	12.9–14.0	11.2–12.4	5.3–5.6	7.8–9.3
			(3)	(3)			(3)	(4)	(4)	(2)	(4)	(4)	(4)	(4)
	F	1	—	—	25	17	41	28	4.7	14.4	12.7	10.2	5	7.3
Rattus tanezumi	M	15	349 ± 9.8	182 ± 10.9	34 ± 1.7	21 ± 1.0	—	40.7 ± 1.08	6.5 ± 0.31	21.0 ± 1.01	16.6 ± 0.66	15.7 ± 0.58	7.1 ± 0.22	11.4 ± 0.57
			339–373	162–195	31–36	19–23		39.5–42.6	6.0–6.9	19.3–21.9	15.7–17.8	14.8–16.5	6.7–7.5	10.5–12.1
			(12)	(11)	(12)	(12)		(10)	(10)	(5)	(9)	(10)	(11)	(11)
	F	7	358 ± 19.4	188 ± 12.5	35 ± 1.4	21 ± 1.7	—	40.4 ± 1.24	6.4 ± 0.30	20.7 ± 0.62	16.5 ± 0.45	15.5 ± 1.08	6.8 ± 0.33	11.1 ± 0.40
			324–382	173–205	33–36	18–23		38.1–41.7	5.9–6.8	19.9–21.2	15.9–17.2 (6)	14.0–16.9	6.5–7.2	10.7–11.8
										(4)		(5)	(6)	(6)

FMNH); Site 8 (2 FMNH); Site 11 (4 DMNH); Site 12 (1 DMNH); Site 13 (2 DMNH).

Rattus exulans (Peale, 1848)

Known as the Polynesian rat or the spiny rice-field rat, *R. exulans* is not native to the Philippines; through mostly accidental dispersal by humans, it occurs from Bangladesh to Easter Island and throughout the Philippines, especially as a pest in agricultural areas. On Camiguin, we found this small (60–75 g) rat to be moderately common in heavily disturbed lowland agricultural land at ca. 150 m (Site 3) and in primary montane forest at 1275 m (Site 7) but not at other sites. Records from the 1960s also show it to be present in mossy forest at ca. 1500 m. This distribution is similar to that found on Negros, where it occurs in high-density agricultural areas and in mossy forest at an elevation of 1500–1650 m (Heideman et al., 1987; Heaney et al., 1989). Both Camiguin and Negros have very few native rodents, and this may influence the ability of nonnative species to invade the forest since the nonnatives are absent or very rare in mature forest on species-rich islands such as Leyte, Luzon, and Mindanao (Heaney et al., 1989, 1999, unpubl. data; Rickart et al., 1993).

In March 1995, one nulliparous female weighing 41 g was trapped. Two adult males (71–76 g) with scrotal testes and two young adults (49–61 g) with scrotal testes were trapped at the same time. They typically become reproductive at a young age and have many large litters each year (Barbehenn et al., 1973). Cranial and external measurements (Table 6) are comparable to those of Dinagat, Leyte, and Mindanao (Mt. Kitanglad), but slight variations in most dimensions are discernible (Heaney & Rabor, 1982; Rickart et al., 1993; Heaney et al., unpubl. data).

SPECIMENS EXAMINED—Total 15. Site 3 (2 MSU-IIT); Site 7 (5 FMNH); Site 12 (1 DMNH); Site 13 (7 DMNH).

Rattus tanezumi Temminck, 1844

Previously known in the Philippines as *Rattus rattus* and *Rattus mindanensis*, the Oriental house rat is a widespread nonnative rodent in the Philippines; it occurs from Afghanistan to Indomalaya, New Guinea, and Micronesia (Musser & Carleton, 1993). This 140–200-g rat is most often found as a pest in urban and agricultural areas but can be common in disturbed forest up to 1800 m (Heideman et al., 1987; Heaney et al., 1989, 1991, 1998, unpubl. data; Rickart et al., 1993). On Camiguin, we found *R. tanezumi* to be very abundant in heavily disturbed agricultural land at 150 m (Site 3; Table 1). It was less common in secondary lowland forest at 1000 m and in disturbed lower montane forest at 1000 m (Site 4) and 1200 m (Site 5), and a single individual was trapped in primary mossy forest at 1400 m (Site 6). Four nestling juveniles were found in a new slash-and-burn clearing near Site 7, but no *R. tanezumi* were caught in adjacent mature forest. Taken together with records from the 1960s, these data indicate that *R. tanezumi* occurs from sea level to the highest peaks on Camiguin, although it tends to be most common at lower elevations and in disturbed habitats.

Pregnant females had a mean weight of 126 ± 57.6 g (range = 63–200 g, N = 4). Females with large mammae but not pregnant had a mean weight of 151 ± 16.7 g (range = 130–169 g, N = 9); three of these had placental scars (three, four, and eight scars). Nulliparous females had a mean weight of 93 ± 39.8 g (range = 67–160 g). Males with scrotal testes had a mean weight of 169.4 ± 22.7 g (range = 141–199 g, N = 8); a subadult with scrotal testes weighed 105 g. These data indicate large litter size (up to eight) and very early reproduction, as is typical for the species (Barbehenn et al., 1973). External and cranial measurements (Table 6) are comparable to those of Biliran, Leyte, Maripipi, and Mindanao, with only slight variation.

SPECIMENS EXAMINED—Total 69. Site 3 (21 MSU-IIT); Site 5 (4 MSU-IIT); Site 6 (1 MSU-IIT); Site 7 (4 FMNH); Site 9 (2 DMNH); Site 10 (6 DMNH); Site 11 (3 DMNH); Site 12 (6 DMNH); Site 13 (22 DMNH).

Order Carnivora

Family Viverridae—Civets

Paradoxurus hermaphroditus Jourdan, 1837

The common palm civet occurs from Sri Lanka to Hainan and the Lesser Sunda Islands and is widespread in the Philippines (Heaney et al., 1998). It has been recorded in agricultural and forested areas from sea level up to at least 2400 m (Heaney et al., 1991, 1999, unpubl. data). We did not capture any palm civets, but in March 1995 we were given a mandible from a specimen taken by local hunters in the mountains above Mahinog, thus confirming the earlier report by Gray (1843). A local hunter identified *P. hermaphroditus* from pictures as being common on Camiguin.

Specimens Examined—Total 1. (1 fmnh).

Viverra tangalunga Gray, 1832

The Malay civet (or tangalung) is found from peninsular Malaysia to Sulawesi and is widespread in the Philippines (Heaney et al., 1998). It has been found in primary and secondary lowland, montane, and mossy forest from sea level to at least 1700 m (Rickart et al., 1993; Heaney et al., 1999). We did not obtain any on Camiguin, but a local hunter identified *Viverra tangaluuga* from photographs as being present on Camiguin; we tentatively accept this as a valid record.

Order Artiodactyla
Family Suidae—Pigs

Sus philippensis Nehring, 1886

The Philippine warty pig is a Philippine endemic that occurs in the Greater Luzon, Greater Mindanao, and Mindoro faunal regions; its numbers are declining (Oliver, 1992, 1999). It formerly was abundant from sea level to at least 2800 m in all habitats; now it is common only in remote forests (Heaney et al., 1991, 1999, unpubl. data; Oliver, 1992, 1999; Garcia & Deocampo, 1997).

On Camiguin in March 1995, we observed hoof marks of wild pigs from disturbed lowland forest at 1000 m up to primary montane forest at 1275 m elevation (Site 7). Near the sampling site at 1475 m (Site 8), we saw an active pig nest, and scattered pig trails were in clear evidence. A local hunter said that they were commonly hunted and often sold in a small local market at Owakan, Mahinog Municipality, but not in coastal cities. We were given two adult mandibles by hunters from pigs captured in forest in the early 1990s in the mountains above Mahinog.

Specimens Examined—Total 2. Above Mahinog (2 fmnh).

Analysis and Discussion

Adequacy of Sampling: What Is Present and What Is Absent?

Before interpreting field data, it is necessary to evaluate the extent to which they are complete and reliable. In doing so here, we follow the procedures used by Heaney et al. (1989, 1991, 1999) and Rickart et al. (1993).

Fruit Bats—Because pteropodid bats lack sonar systems, they are easily captured in mist nets. The 1960s surveys, which focused on birds, yielded many fruit bat specimens (Heaney, 1984), most of them almost certainly from mist nets. Those efforts obtained six species of fruit bats (Fig. 2). Our netting in 1992–1994 yielded no additional species but was not extensive. We consider it quite possible that some additional species may be present, especially *Eonycteris spelaea* and *Rousettus amplexicaudatus*, since both occur very widely in the Philippines (Heaney et al., 1998), and possibly the large *Acerodon jubatus* and *Pteropus vampyrus*, which fly high above the canopy and so are difficult to capture. However, our sampling was sufficient that we consider it quite unlikely that the species that are abundant and easily captured on Mindanao and associated islands (Heaney et al., 1989, unpubl. data; Rickart et al., 1993) are present on Camiguin, especially *Haplonycteris fischeri* and *Ptenochirus minor* and probably *Megaerops ecaudatus*. Suitable habitat for the high-elevation specialist *Alionycteris paucidentata* is very limited in area on Camiguin, if present at all; although we did limited netting in that habitat, we think it very unlikely that this species is present.

Sampling along the elevation gradient probably has produced a partial picture of variation in species richness (Fig. 2) but as noted may be incomplete because our netting in 1992–1995 was not extensive (Table 3).

Insectivorous Bats—Insectivorous bats use sophisticated sonar systems to navigate. They are thus difficult to capture in mist nets, which were our only means of capturing them; further, our mist-netting efforts in 1992–1995 were limited in extent (see Heaney & Tabaranza, 2006a; Table 3). For this reason, we believe that our sample of six species is likely to be quite incomplete and is not usable for estimates of species richness, as is often the case (Heaney et al., 2002). Our data contribute, however, to general knowledge of the natural history of these poorly known animals.

Nonvolant Small Mammals—Shrews, rodents, and other small mammals that can be captured in traps were poorly sampled by the 1960s field teams, which focused their efforts on birds (and secondarily on fruit bats). During 1994 and 1995, we accumulated 2783 trap-nights at six sites that included all major habitat types on the island, yielding 188 captures (Table 1). A species-accumulation curve for these data (Fig. 3) shows that the number of species recorded for

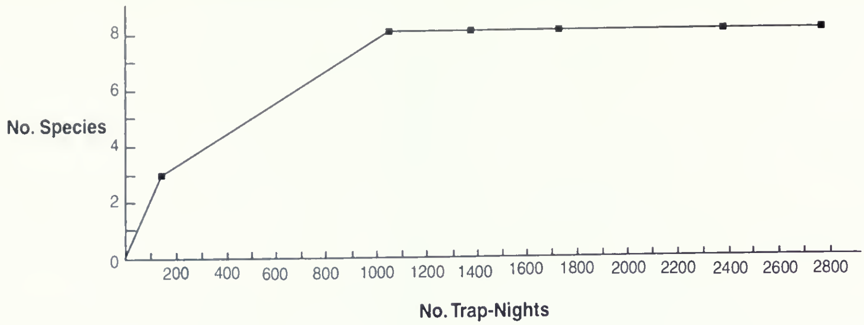

FIG. 3. Species accumulation curve for nonvolant small mammals on Camiguin Island. The points shown are for Sites 1 and 3 to 6, as described in the text.

the island reached a peak of eight species (including five nonnative species) by the end of sampling at the second site (1055 trap-nights) and showed no further gain as we approached the total of nearly 2800 trap-nights. Local hunters either were unfamiliar with squirrels or knew them from Mindanao; given their conspicuousness (Heaney et al., unpubl. data), they are very unlikely to be present. We conclude that the island is unlikely to support other species of small mammals that are present on Mindanao, including gymnures (*Podogymnura*), tree shrews (*Urogale*), squirrels, or murid rodents (e.g., *Batomys*, *Limnomys*, and *Tarsomys*). Further, the sampling along the elevational gradients was sufficiently intense that we are likely to have an accurate assessment of the pattern of species richness above about 800 m, although it must be noted that extensive habitat destruction at lower elevations may have had an extensive impact on the current patterns (discussed below).

MEDIUM AND LARGE MAMMALS—We collected information only on the presence and absence of large mammals and a mixed set of medium-sized species (none of which are readily captured in traps such as the ones we used), not on detailed habitat use. We observed carefully during all our time in the field for any evidence of additional species, and we interviewed many residents of the islands and showed them photos of potential species: some of these residents are active hunters. Neither we nor our informants had any evidence for tarsiers, flying lemurs, or deer on the island, though many people knew of deer and tarsiers on Mindanao, and a few knew of flying squirrels and flying lemurs. We consider it unlikely that species other than those listed here are present given the voucher specimens we obtained and the concordance between our specimens and the information received from local hunters. Thus, we conclude that deer are absent, along with the smaller but conspicuous species such as tarsiers, squirrels, and flying lemurs.

Elevational Patterns

Though our limited netting prevents us from commenting on the patterns of diversity and abundance of bats along the elevational gradient on Camiguin, our trapping data (Table 1) provide a reasonably complete picture of the general patterns among nonvolant species. The highest density we encountered was at Site 3, in agricultural land at ca. 150 m. However, these were all nonnative rats and a shrew, representing only three species, a pattern that we have often seen (e.g., Heaney et al., 1989; Rickart et al., 1991). The five native small mammal species were all present (or suspect to be present) from 1000 to 1300 m and declined in species richness to two species near the peak of Mt. Timpoong at Site 8 (Table 1). Density (measured as the number captured per 100 trap-nights) more than doubled from 1000 to 1275 m, then fell to a much lower level near the peak at 1475 m. However, much of the change in density was driven by the remarkably large numbers of *Suncus murinus* at the upper elevations; they were not taken at 1000 or 1200 m (though they were taken at 150 m), were fairly common at 1300 and 1475 m, and were exceptionally abundant at 1275 m, where we often saw and heard them during the day. These patterns for species richness, though limited in extent, are similar to those from elsewhere in the Philippines, where species

richness is generally low at low elevations, increases to about the area of transition from montane to mossy forest, and declines with increasing elevation in mossy forest (Rickart et al., 1991; Heaney, 2001). The pattern of overall abundance is also similar to that documented elsewhere, except that *Suncus murinus* is remarkably abundant in the high-elevation montane and mossy forest, where usually it is absent (Heaney, 2001). We have previously noted the abundance of *S. murinus* in similar habitat only once, on Negros Island (Heaney et al., 1989), which is notably depauperate of small mammals (Heaney, 1986). This raises a question: Is Camiguin depauperate, relative to its area, in comparison to other islands in the Philippines? This question is addressed in the next section.

Biogeographic Implications

Bats—Because our focus in conducting field studies concentrated primarily on nonvolant mammals, we note only that we are confident that the fruit bat community on Camiguin is at least somewhat depauperate relative to similar elevations on Mindanao and associated islands. At least two species usually common at lower and middle elevations, *Haplonycteris fischeri* and *Ptenochirus minor*, are almost certainly absent. Both of these are primarily associated with old-growth rain forest and generally do not travel long distances out from under the canopy of forest (Heaney et al., 1989, 1998; Heideman & Heaney, 1989; Rickart et al., 1993). Some additional species probably also are absent (*Alionycteris paucidentata* and *Megaerops wetmorei*); they also are associated with old-growth rain forest, though *A. paucidentata* in a distinctive high-elevation habitat (*M. wetmorei* is poorly known). This level of reduction in species richness is striking in view of the tight correlation between species richness and island area previously found (Heaney, 1991a). However, the uncertainty regarding the potential absence of *Eonycteris* and *Rousettus* leads us to be cautious in defining the extent to which species richness is low.

Nonvolant Mammals—The data are more certain regarding both small mammals (shrews and murid rodents) and the medium and larger mammals (deer, squirrels, and so on). It seems certain that many genera present in the lowlands and in montane habitats on Mindanao and associated islands are absent: tree shrews (*Urogale*), flying lemurs (*Cynocephalus*), tarsiers (*Tarsius*), tree squirrels (*Sundasciurus*), pygmy squirrels (*Exilisciurus*), flying squirrels (*Petinomys*), a murid (*Tarsomys echinatus*), and deer (*Cervus*). Among the murid rodents, *Batomys* is also absent though often found in montane forest on Mindanao and associated islands (Rickart et al., 1993). *Limnomys bryophilus*, *L. sibuanus*, and *Tarsomys apoensis* also occur on Mindanao but only above about 1900 m elevation (Musser & Heaney, 1992; Heaney et al., 1998; Rickart et al., 2003).

Those species of nonvolant mammals that are present on Camiguin form a group that is quite consistent in one respect. Not all lowland species from Mindanao are present, but all those that are present on Camiguin are among the relatively few species that are common in the lowlands of Mindanao—or were present before human destruction of lowland rain forests. As shown by Musser and Heaney (1992), Heaney (2001), and Heaney et al. (unpubl. data), *Crocidura*, *Apomys*, *Bullimus*, *Crunomys*, *Rattus everetti*, *Paradoxurus*, *Viverra*, and *Sus* are among the few mammals that occur (or occurred until recently) on Mindanao in lowland forest. With only one exception (*Tarsomys echinatus*), all those lowland species of Mindanao noted above as being absent from Camiguin are arboreal species. In other words, the nonvolant mammal fauna of Camiguin is composed only of nonarboreal small mammals from Mindanao (or are their sister taxa) and all the lowland larger mammals (all of which are also not arboreal). We conclude that the mammalian fauna of Camiguin is highly biased; that is, it is composed entirely of species shared with and/or derived from Mindanao, but it is not a random sample of the Mindanao fauna; rather, it is comprised of species that occur (or occurred before deforestation) on the lowland forest floor of Mindanao, not in the forest canopy and not in the montane or mossy forest.

Does the absence of arboreal mammals mean that Camiguin has a species-poor nonvolant mammal fauna relative to other islands in the Philippines? Perhaps surprisingly, the answer is clearly no. With nine native nonvolant mammals, Camiguin falls almost precisely on the same species-area curve as the islands that made up Greater Mindanao (Mindanao, Leyte, Bohol, Biliran, and Maripipi). While the fauna is biased toward lowland, ground-living murid rodents, and small omnivorous carnivores, the species

richness is not reduced relative to islands that were recently connected to Mindanao itself (Heaney, 1986; Rickart et al., 1993). However, the nonvolant small mammal community is apparently sufficiently species-poor to allow a nonnative shrew (*Suncus murinus*) to invade primary montane forest. The presence of this shrew in similar habitat has been noted on Negros Island, which is also species poor (Heaney et al., 1989), but not on other islands in the Philippines (e.g., Rickart et al., 1991, 1993). We predict that *S. murinus* will be found in primary montane forest on other islands in the Philippines with five or fewer native shrews and rodents.

Conservation and Management

As noted by Heaney and Tabaranza (1997, 2006a), the native mammal fauna of Camiguin is dependent on the continued survival of good-quality forest at all elevations. The two mammal species unique to Camiguin, in particular, apparently depend on forest with little or no disturbance, most of which currently occurs in steep areas above 800 m elevation. These forested areas are also crucial to the well-being and stability of the human population, for they are the source of water for the island and protect the lowlands from potentially devastating floods and landslides. Additionally, our observations indicate that the medium and large mammals have been depleted by overhunting; these require protection if they are to survive. The people of Camiguin benefit both personally and economically from the beautiful landscape and seashores of the island, both through the tourism they make possible and from the environmental stability they engender. Protecting the forests will benefit the people and wildlife equally.

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4

A New Species of Hanging-Parrot (Aves: Psittacidae: *Loriculus*) from Camiguin Island, Philippines

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Abstract

A new species of Hanging-Parrot or Colasisi, *Loriculus*, is described from a series of 23 specimens (19 males, 4 females) collected in the 1960s on Camiguin Island, Camiguin Province, Philippines, at elevations between 300 and 1350 m. The new species lacks sexual dimorphism in plumage coloration, which distinguishes it from all other members of the *L. philippensis* group and all other *Loriculus*. The overall color pattern of the new species appears most like females of *L. p. worcesteri* and *L. p. apicalis* but differs in plumage characteristics (the width and extension of the orange-scarlet crown patch, the amount and intensity of blue in the face and thighs, and the intensity of the blue in the tail above inner edges and the tail below). In addition, males of the new species are larger than males of nearby populations of *L. philippensis*, having significantly longer tails and wing chords. Nothing is known about the habits of the new species; however, the small size of the island of Camiguin, coupled with extensive deforestation, makes the status of the new species a significant conservation concern.

Introduction

The Philippine Hanging-Parrot or Colasisi (*Loriculus philippensis*) has ten described subspecies distributed throughout the islands of the Philippines (Dickinson et al., 1991; Collar, 1997; Juniper & Parr, 1998; Kennedy et al., 2000). The subspecies *L. p. apicalis* has been reported to occur on the islands of Bazol, Balut, Camiguin, Dinagat, Mindanao, and Siargao (Fig. 1). However, Austin Rand, a former Field Museum curator and Philippine expert (e.g., Rand & Rabor 1960, 1969), had penciled the notation "subsp. nov" on the tag of a specimen from Camiguin in the FMNH collection. He never published a description. Here, we quantitatively evaluate the external morphology and compare the plumage color of specimens referred to *L. p. apicalis* from Camiguin with *L. p. apicalis* from Mindanao and specimens of other subspecies of *L. philippensis*. Our results demonstrate that the Camiguin population of *L. p. apicalis* is separable from all other populations of *L. philippensis* in plumage. It is further separable from all neighboring populations in body size. We argue that these differences warrant designating this population as a distinct species and not a subspecies of *L. philippensis*. Similar arguments have been made in separating *L. bonapartei* of the Sulu Archipelago from the *L. philippensis* complex (Juniper & Parr 1998). We present a formal

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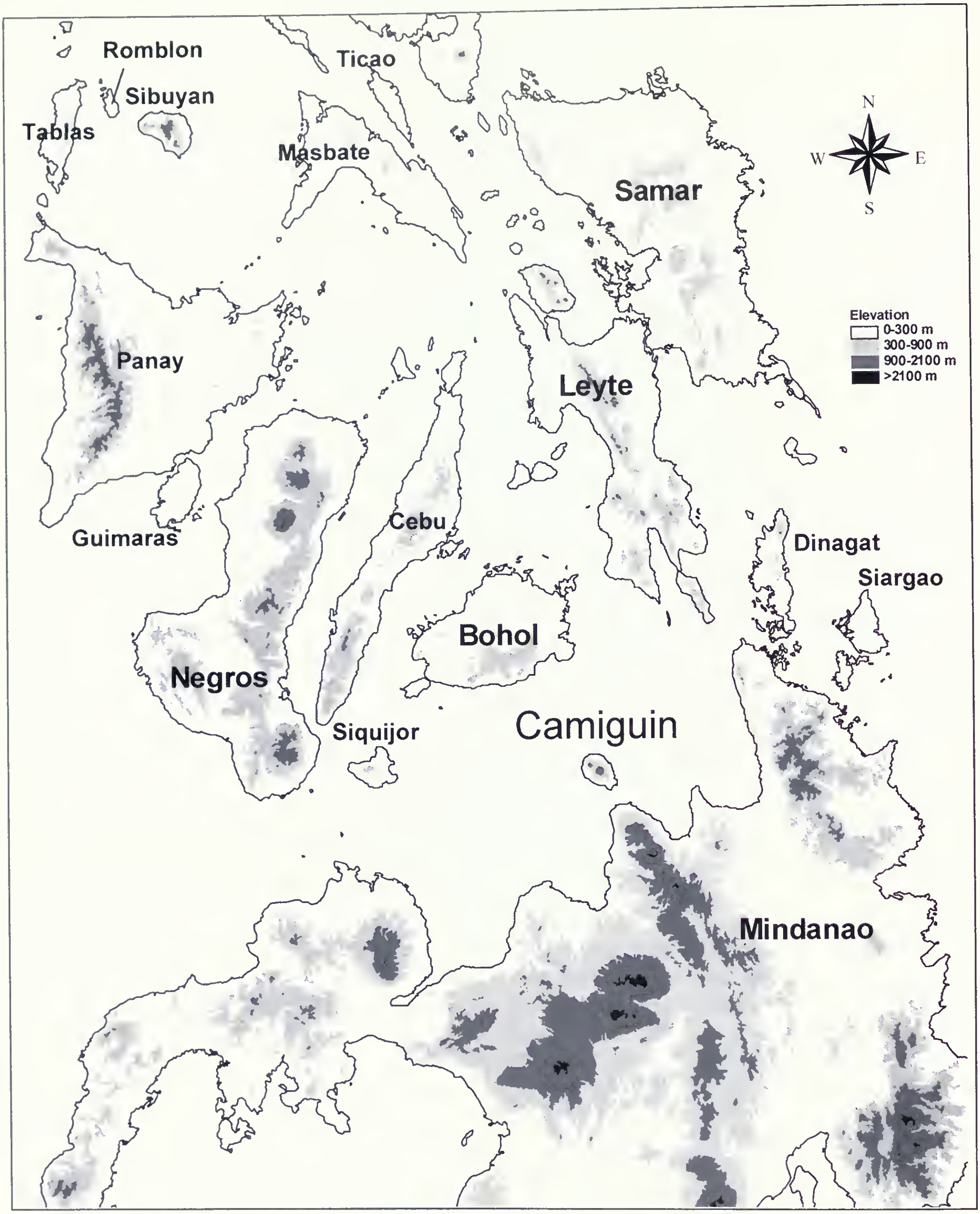

FIG. 1. Map of the central and southern Philippines showing the locations of islands referred to in the text.

description of the new taxon based on plumage and morphology of adult males.

Methods

All qualitative color comparisons were made under natural light. Color names follow Smithe (1975), and each color name (capitalized) is followed by its number in parentheses. J.F.D. measured wing chord, tarsus length, tail length (from point of insertion of central rectrices to tip of longest rectrix), culmen length, bill length (from anterior edge of nostril), bill height (at anterior edge of nostril), bill width (at anterior edge of nostril), and gape width with calipers to the nearest 0.05 mm. Specimens were measured randomly to avoid any investigator bias.

All statistical analyses were carried out using the program Statistica (Statsoft Inc. 1995). Mensural data were tested for normality using Kolmogorov–Smirnov tests and Lilliefors probabilities prior to all the analyses. Mensural differences between males and females within each study population were evaluated using one-way analyses of variance (ANOVAs). We used both univariate (one-way ANOVAs and Bonferroni post hoc tests) and multivariate analysis (principal components and discriminant function) on log-transformed data to test for mensural differences between specimens from Camiguin and those from neighboring populations of *L. philippensis*. Multivariate analyses were used to reduce the dimensionality of data and facilitate the analysis of morphology in two or three dimensions (Pimentel, 1979); we used the varimax raw method to rotate the three components that are reported in the principal components analysis in order to improve interpretability of the resulting patterns. Collecting localities are described by Heaney and Tabaranza (2006a).

Loriculus camiguinensis, new species

Camiguin Hanging-Parrot

Holotype—Field Museum of Natural History No. 284389, adult male from Kasangsangan, Municipality of Catarman, Camiguin Province, Camiguin Island, Philippines, elevation between 1000 and 2000 ft (300–600 m; approx. 9°11′N, 124°40′E; see Heaney & Tabaranza, 2006a, for more explanation of this and other collecting localities on Camiguin Island), 18 June 1968, collected by D. S. Rabor and W. Sanguila.

Diagnosis—A *Loriculus* hanging-parrot with characteristics of the *philippensis* group (see Front Plate). In contrast to other members of this group, *L. camiguinensis* is characterized by a lack of sexual dimorphism in plumage coloration. The overall color pattern of *L. camiguinensis* is most like females of *L. p. worcesteri* from Bohol, Leyte, and Samar and *L. p. apicalis* from Mindanao but differs as follows: (1) the scarlet of the crown of *L. camiguinensis* does not extend as far onto the bright olive green nape as it does in both males and females of *L. p. apicalis* and *L. p. worcesteri*; this pattern differs from that of *chrysonotus*, *siquijorensis*, *regulus*, *bournsi*, *mindorensis*, and *philippensis*, in which the scarlet crown is highly reduced. (2) The width of the scarlet crown in *L. camiguinensis* narrows at the rear edge instead of being rounded as in all other populations. (3) The scarlet (sometimes orange) throat patch that is typical of males in *L. philippensis* is lacking in *L. camiguinensis*; five of the Camiguin males had data on gonadal development, reporting enlarged or slightly enlarged testicles, which gives an indication of their adult condition. (4) The face of *L. camiguinensis* is extensively turquoise blue and differs from that of females of *L. philippensis* subspecies in that the blue of the face is darker and more extensive, extending over the eye and onto the throat. (5) The turquoise blue in the thighs of *L. camiguinensis* is darker than that of females of *L. philippensis* populations. (6) The blue in the inner edges of the rectrices above and throughout below is darker in *L. camiguinensis*. (7) Mean wing chord and tail length of males and tail length of females of *L. camiguinensis* are significantly longer than those of nearby *L. philippensis* subspecies (Tables 1 and 2). (8) The overall green plumage is a darker shade with less of a yellowish tinge, especially on the back.

Description of Holotype—General plumage Parrot Green (160) with slightly orange tinge in the upperparts, more yellowish tinge on underparts; forehead and forepart of crown Scarlet (14) fading to orange at rear-edge; thin Orange Yellow (18) band on nape; lores, chin, cheek, and throat closest to Turquoise Blue (65); rump and upper tail-coverts scarlet; Turquoise Green (64) markings on the sides of the rump; thighs slightly paler Turquoise Blue; rectrices Emerald Dark Green (262) above with dark Cerulean Blue (67)

tinges on inner edges of all but central rectrices; rectrices dark Cerulean Blue below; flight feathers black above with Emerald Dark Green outer edges, flight feathers black below with inner edges with extensive Cerulean Blue; greater underwing-coverts Cerulean Blue and lesser underwing-coverts closest to Spectrum Green (62). Soft part colors of dried specimen: upper mandible closest to Spectrum Orange (17) at base grading to yellow with Gray Horn (91) at tip and along tomia; lower mandible with similar pattern, but orange at the base; cere Grayish-Horn; feet and tarsi, yellow-horn.

Measurements of Holotype (mm)—Wing (99.8), tarsus (11.7), tail (49.5), culmen (18.0), bill length (15.0), bill height (11.1), bill width (6.4), gape width (8.2).

Distribution—*Loriculus camiguinensis* is known only from the forests of Camiguin Island. Specimens have been collected between 1000 and 4500 ft (300–1350 m) in the municipalities of Catarman and Mahinog (Balete et al., 2006; Heaney & Tabaranza, 2006a).

Etymology—We name this species after the Philippine Island of Camiguin, to which this species appears to be endemic.

Specimens Examined—We examined the following specimens from Field Museum of Natural History (FMNH) and Delaware Museum of Natural History (DMNH):

L. camiguinensis (Camiguin Island) (19 males, 4 females, all known specimens of this new taxon): Camiguin Province: Catarman Municipality; Kasangsangan (males: FMNH holotype, FMNH 284391, 284392, 284393; DMNH 19950, 19958, 19960, 19961, 19962: females FMNH 284390; DMNH 19959); Camiguin Province: Catarman Municipality; Catarman Mountain (male: DMNH 19949); Camiguin Province: Mahinog Municipality; Matugnao, Mt. Timpoong (males: FMNH 286742, 286743, 286744, 286745; DMNH 19951, 19952, 19953, 19954, 19965; females: FMNH 286746, 286747).

L. p. apicalis (Mindanao Island) (19 males, 5 females): North Cotabato Province: Mt. Apo, Todaya (male: FMNH 184090); North Cotabato Province: Mt. Apo, Galog (male: DMNH 36227); Agusan del Norte: Mt. Hilong-Hilong, Lewed (male: FMNH 275003); Misamis Occidental: Zamboanga Peninsula, Mt. Malindang, Gandwan (males: FMNH 227136, 227138, 227139; female: FMNH 227137); Misamis Occidental: Zamboanga Peninsula, Mt. Malindang, Masawan (males: FMNH 227134, 227135); Davao Oriental Province; Mati: Mt. Mayo, Limot (male: FMNH 277864); Misamis Oriental Province: Manticao: Tuod, Camp Dundue (male: FMNH 283788; female FMNH 283787); Misamis Oriental Province: Opol: Malubato (male: FMNH 283785); South Cotabato: Tupi: Mt. Matutum (male: FMNH 279330); Bukidnon Province: Malaybalay, Mt. Katanglad (male: FMNH 262475, 262476; female: FMNH 262474); Bukidnon Province: Lantapan: Kotoon, Mt. Katanglad SE slope (male: DMNH 2983); Lanao Norte Province: Iligan City, Mainit, Mahayahay (female: FMNH 283786); Surigao del Sur Province: Car-Can-Mad-Lan area (female: FMNH 275002); Zamboanga del Sur Province: Zamboanga (male: DMNH 36993); Davao Oriental Province: Sigaboy (males: DMNH 36224, 36226); Davao del Sur Province: Padada (male: DMNH 36233).

L. p. worcesteri (11 males, 8 females): Bohol Island: Bohol Province: Sierra Bullones (males: FMNH 223025, 223026, 223029, 223030, 223034, 223036, 223037; females: FMNH 223027, 223327, 223028, 223033, 223035, 223039); Leyte Island: Leyte Province: Burauen, Buri, Ma-Alngon (male: FMNH 276302; female: FMNH 276300); Leyte Province: Burauen, Buri, Mt. Lobi range, Tambis (male: FMNH 276299; female: FMNH 276298); Samar Province: Mt. Capotoan (male: FMNH 247411); Western Samar Province: Matuguinao (male: FMNH 247410).

L. p. regulus (Negros Island) (5 males, 4 females): Negros Oriental Province: Bayawan, Basay (male: FMNH 257121); Negros Oriental Province: Santa Catalina, Inubungan (male: FMNH 219314; male: FMNH 188579); Negros Oriental Province: Sicopon River (male: FMNH 185483); Negros Oriental Province: Amio (males: FMNH 188545, 188548; females: FMNH 188544, 188553); Negros Oriental Province: Pamo-at (male: FMNH 188550).

L. p. chrysonotus (captive specimen, presumably from Cebu Island) (1 male): Cebu Province: Exact locality unknown (FMNH 252666).

L. p. siquijorensis (Siquijor Island) (1 male): Siquijor Province: San Juan: Tag-ibo (FMNH 222741).

L. p. bournsi (Sibuyan Island) (1 male, 1 female): Romblon Province: Goangan, 3 km SE Magdiwang (male: FMNH 358288); Romblon Province: Exact locality unknown (female: FMNH 11081).

L. p. mindorensis (Mindoro Island) (1 male, 1 female): Oriental Mindoro Province: Calapan (male: FMNH 19927); Occidental Mind-

TABLE 1. Ranges, means (±SE), and sample sizes of selected measurements (mm) of *L. camiguinensis* and neighboring populations of *L. philippensis*. One–way analysis of variance tests comparing differences due to sex within each population. *Significant at $P<0.05$, but non-significant when P-values were adjusted for the number of simultaneous tests, 0.05/16=0.003.

	L. camiguinensis		*L. p. apicalis*		*L. p. worcesteri*		*L. p. regulus*	
Characters	♂	♀	♂	♀	♂	♀	♂	♀
Wing chord	93.1–100.0 97.6 ± 0.5 *n* = 18	95.7–103.0 99.3 ± 1.5 *n* = 4	87.1–98.3 91.8 ± 0.6 *n* = 19	90.1–94.1 92.6 ± 0.9 *n* = 4	88.6–93.8 91.7 ± 0.5 *n* = 11	85.2–97.0 92.4 ± 1.2 *n* = 8	90.5–94.2 92.1 ± 0.8 *n* = 4	91.2–93.2 92.4 ± 0.6 *n* = 3
Tarsus length	10.4–12.9 11.5 ± 0.1 *n* = 18	11.3–12.4 11.9 ± 0.3 *n* = 3	9.0–11.5 10.3 ± 0.2 *n* = 19	9.5–11.0 10.1 ± 0.3 *n* = 4	9.5–11.3 10.3 ± 0.2 *n* = 11	10.1–11.3 10.8 ± 0.1 *n* = 8	9.2–11.0 10.2 ± 0.4 *n* = 5	10.8–11.7 11.2 ± 0.2 *n* = 4
Tail length	42.6–50.5 47.8 ± 0.5 *n* = 17	47.5–53.6 50.3 ± 1.4* *n* = 4	38.1–45.8 42.9 ± 0.5 *n* = 19	42.4–47.4 44.4 ± 1.1 *n* = 4	41.8–46.1 44.4 ± 0.5 *n* = 11	38.2–47.1 44.6 ± 1.0 *n* = 8	42.7–43.7 43.2 ± 0.2 *n* = 5	43.2–48.6 44.8 ± 1.3 *n* = 4
Culmen length	17.5–19.2 18.2 ± 0.1 *n* = 18	17.1–19.0 17.8 ± 0.4 *n* = 4	16.2–18.2 17.4 ± 0.1 *n* = 19	17.2–17.6 17.4 ± 0.1 *n* = 4	16.0–19.2 17.7 ± 0.3 *n* = 11	16.4–17.8 17.1 ± 0.2 *n* = 8	16.5–19.0 17.8 ± 0.4 *n* = 5	16.4–17.2 16.8 ± 0.2 *n* = 4
Bill length	13.6–15.0 14.3 ± 0.1* *n* = 18	12.4–14.8 13.5 ± 0.5 *n* = 4	12.5–14.3 13.5 ± 0.1 *n* = 19	12.9–13.2 13.0 ± 0.1 *n* = 4	11.7–14.6 13.7 ± 0.3 *n* = 11	12.4–13.2 13.0 ± 0.1 *n* = 8	13.1–14.5 13.7 ± 0.3 *n* = 5	12.0–13.4 12.6 ± 0.3 *n* = 4
Bill height	9.2–11.1 10.3 ± 0.2 *n* = 14	9.3–10.8 10.1 ± 0.3 *n* = 4	8.1–11.0 9.7 ± 0.2 *n* = 15	9.5–10.8 10.0 ± 0.3 *n* = 4	9.4–11.4 10.2 ± 0.2* *n* = 10	9.3–9.9 9.6 ± 0.1 *n* = 6	9.0–9.6 9.3 ± 0.1* *n* = 5	8.6–9.4 9.0 ± 0.2 *n* = 4
Bill width	6.1–7.5 6.6 ± 0.1 *n* = 18	6.0–6.8 6.4 ± 0.2 *n* = 4	5.4–7.2 6.0 ± 0.1 *n* = 19	5.8–6.2 6.1 ± 0.1 *n* = 4	5.5–7.0 6.3 ± 0.2 *n* = 10	5.8–6.2 6.0 ± 0.1 *n* = 7	5.5–6.3 6.0 ± 0.1 *n* = 5	5.3–6.4 5.8 ± 0.2 *n* = 4
Gape width	7.2–8.8 7.9 ± 0.1 *n* = 18	7.3–8.0 7.6 ± 0.2 *n* = 4	6.1–7.9 7.2 ± 0.1 *n* = 19	7.2–8.0 7.4 ±0.2 *n* = 4	6.7–8.1 7.3 ± 0.1 *n* = 10	6.8–7.5 7.1 ± 0.1 *n* = 7	7.2–7.6 7.4 ± 0.1 *n* = 5	7.2–7.8 7.6 ± 0.1 *n* = 4

TABLE 2. Univariate statistical comparisons between *L. camiguinensis* and adjacent populations of *L. philippensis*. Populations (1 = *L. camiguinensis*; 2 = *L. p. apicalis*; 3 = *L. p. worcesteri*; and 4 = *L. p. regulus*) are ordered based on their mean variation, from smallest to largest (left to right). * *F* values significantly different at $P < 0.05$ (one-way analysis of variance and Bonferroni post-hoc test). For each morphometric variable, populations united by the underlines showed non-significant differences.

Morphometric variables	*F*	Populations			
Wing chord	30.5*	2	3	4	1
Tail length	23.1*	2	4	3	1
Tarsus length	14.8*	2	3	4	1
Gape width	9.8*	2	3	4	1
Bill length	3.7*	2	4	3	1
Total culmen	3.5*	2	3	4	1
Bill height	4.0*	4	2	3	1
Bill width	5.2*	2	4	3	1

oro Province: Abra de Ilog (female: FMNH 210845).

L. p. philippensis (Luzon Island) (1 male, 1 female): Bataan Province: Mariveles (male: FMNH 73966); Cagayan Province: Sierra Madre, Mt. Cagua (female: FMNH 258827).

Morphometric Differences—One-way ANOVAs on all known *L. camiguinensis* specimens and specimens in the FMNH collection from neighboring islands showed that certain variables differed between sexes in some of the study populations, but no consistent pattern was found (Table 1). Because of the small sample of females available for this study, we include only males in the analyses.

Results of the one-way ANOVAs (effect = population) and Bonferroni post hoc tests showed that males of *L. camiguinensis* are morphologically distinct from males of other *L. philippensis* populations. Wing chord, tail length, and tarsus length were significantly longer in *L. camiguinensis* males than in the other populations (Table 2).

Principal components analysis for males from all populations resulted in three rotated (varimax raw) factors with Eigenvalues close to or greater than 1.0, which together explained 73.2% of the total variance (Table 3). Axes defined by the first and third component (particularly the third) demonstrate separation of *L. camiguinensis* from the other populations (Fig. 2). The first component explained 45.2% of the total variance and had high positive correlations with bill width, bill height, and gape width (0.80, 0.77, and 0.71, respectively). The second component explained 16.8% of the total variance and had high positive correlation with bill length and culmen length (0.92 and 0.88, respectively). The third component explained a further 11.2% of the variance and had the highest positive correlation values for tail length and wing chord (0.94 and 0.84, respectively). It was this latter axis that differentiates *L. camiguinensis* from the other populations.

TABLE 3. Fraction of total variance explained by each of the first three components of the principal components analyses. The three components were rotated (see Methods).

Morphometric variables	PCI	PCII	PCIII
Wing chord	0.25	0.29	0.84
Tarsus length	0.29	0.31	0.40
Tail length	0.16	0.04	0.94
Total culmen	0.14	0.88	0.18
Bill length	0.05	0.92	0.09
Bill height	0.77	0.15	0.17
Bill width	0.80	−0.04	0.21
Gap width	0.71	0.33	0.35
Eigenvalue	*3.62*	*1.34*	*0.90*
Explained variance (%)	*45.21*	*16.79*	*11.21*

A discriminant function analysis using these morphometric variables was also significant ($P < 0.001$) and correctly classified 88% of the cases (plot not shown). The standardized coefficients of the discriminant function separating males of *L. camiguinensis* from those of other *L. philippensis* populations weighted tarsus length and wing chord heavily (0.80 and 0.80, respectively), followed by tail length (0.46) and bill length (0.40), with all the other variables having coefficients under 0.32.

A Question of Correctly Sexed Specimens—Unpublished concern has been expressed regarding the ability of Rabor and his field assistants to accurately determine the sex of specimens. This possibility presents a serious issue with respect to interpreting the data at hand. In an attempt to verify sexing, we tried unsuccessfully to amplify DNA from toe pads of some specimens using commercially available primers for sex-linked DNA. However, for the following reasons, we remain convinced that there is good reason to believe that the issue of sexing does not overshadow the validity of this taxon. It is our experience that mis-sexing

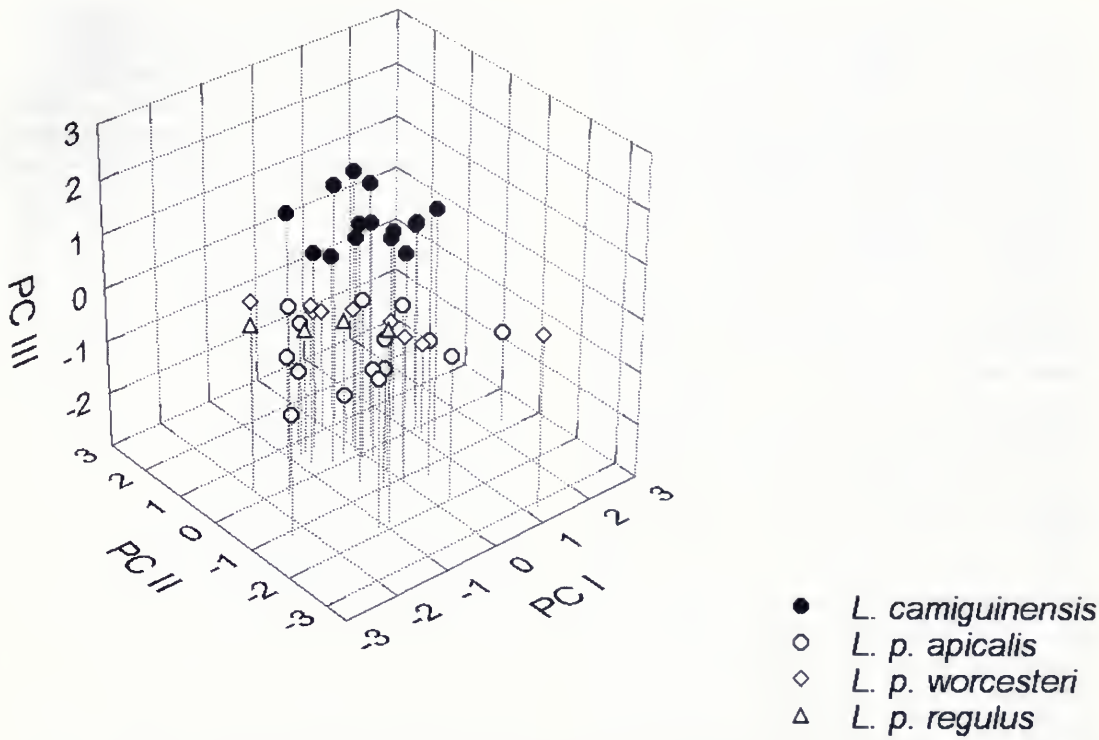

FIG. 2. Results of the Principal Components Analysis of morphological data from populations of Philippine *Loriculus*, on the first three axes; see text for details.

most commonly involves undeveloped gonads, and there are clearly labeled tags indicating that the gonads of some specimens were developed. If mistakes were made, the plumage characters of the specimens described above would logically argue that all males were misidentified as females. Again, this seems highly unlikely given the number of males (19). Furthermore, it seems highly unlikely that a series of 23 randomly collected parrots would all have been females. Certainly, there is nothing like this in other series of *Loriculus* collected by Rabor in other parts of the Philippines. Thus, while we cannot say that all specimens are unequivocally identified to sex correctly, we feel that adults of both males and females are included in these series.

Discussion

Our results demonstrate that *L. camiguinensis* is diagnosable from populations of *L. philippensis* in plumage. It also differs in size from all neighboring populations. We were able to make direct comparisons with specimens of all subspecies except *L. p. dohertyi* (Basilan). It is possible that *L. camiguinensis* is more closely related to some parts of the *L. philippensis* group than others, which would make *L. philippensis* paraphyletic (Funk & Omland 2003). Despite this possible relationship to the widespread *L. philippensis* group, we believe *L. camiguinensis* sufficiently differentiated to be beyond concerns expressed about recognizing new species based on minor morphologic differences (e.g., Collar et al., 1999). Based on geographic distance and the overall pattern of plumage coloration, *L. camiguinensis* most closely resembles populations of *L. p. apicalis* and *L. p. worcesteri*, but no phylogenetic analyses exist yet for these taxa. The comparatively dull plumage of the male of *L. camiguinensis* is consistent with the documented tendency for some insular bird populations to lose bright plumage, leading to a lack of sexual dichromatism (see references in Peterson, 1996); *L. camiguinensis* is the only member of the genus without sexual dichromatism in plumage.

The recognition of this distinctive taxon coincides with recent surveys of the small mammal fauna of Camiguin Island that have discovered two new species of rodents (Rickart et al., 2002; Heaney et al., 2006). Camiguin is believed to be the smallest Philippine island to harbor endemic species of birds and mammals (Heaney & Tabaranza, 1997, 2006a). The island has been continuously isolated from its large southern neighbor, Mindanao, even during periods of low sea level during the "ice ages" of the Pleistocene, when sea levels dropped to 120 m below present levels (Heaney, 1986, 1991a, 1991b; Fairbanks, 1989; Heaney and Tabaranza, 1997, 2005b; Heaney and Regalado, 1998; Hanebuth et al., 2000), and this may have played a role in the differentiation of Camiguin's fauna from that of Mindanao (Steppan et al., 2003).

The value of museum collections is well illustrated with this description. These collections were essential in the recognition and documentation of *L. camiguinensis*. Had there not been a series of specimens available for study, we would have likely dismissed differences in the new taxon as possibly aberrant or immature plumage or an error in sexing of a specimen (a female incorrectly identified as a male; see above). However, the presence of a series of specimens from different localities (with data on gonadal development) has allowed us to compile meaningful data sets on morphological variation and assess within-population variation in color.

This new species also illustrates the need for additional taxonomic and systematic research on the *Loriculus* hanging-parrots to understand the evolutionary patterns in the group and to evaluate the possibility that some of the other allopatric forms of *L. philippensis* may also deserve species status. The issue of assessing the taxonomic status of allopatric populations in the Philippines has long been recognized as a challenge for conservationists (Collar et al., 1999; Peterson et al., 2000). To date, little attention has been given to the conservation plight of *Loriculus* parrots. For instance, none was included by Collar et al. (1999) in their list of threatened Philippine bird species. This lack of attention can be directly correlated with the designation of *L. philippensis* as a polytypic species. The plight of these populations is cause for concern, as *Loriculus p. chrysonotus* from the island of Cebu is believed to be extinct (Forshaw, 1989; Mallari et al., 2001) and another form, *L. p. siquijorensis*, may be extinct as well (Forshaw, 1989; Kennedy et al., 2000). The combined populations of Mindoro, Sibuyan, Negros, Panay, Tablas, Romblon, Masbate, Ticao, Guimaras, and Basilan (including *mindorensis*, *bournsi*, *regulus*, and *dohertyi*) may total no more than 5000 individuals (Juniper & Parr, 1998). The current population size of *L. camiguinensis* is not known (but see Heaney and Tabaranza, 2006a, for an assessment of remaining habitat on the island). Without field data on its status, we defer from suggesting how this species should be characterized under international threat criteria (IUCN Species Survival Commission, 1994). However, because Camiguin is a small island that has experienced extensive deforestation, the conservation status of this newly described species clearly requires assessment. Field study is needed to establish the population size and requirements as a prerequisite for conservation planning and action.

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5

An Annotated Checklist of the Birds of Camiguin Island, Philippines

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Abstract

Fifty-five species of resident breeding and two species of migratory land birds have been documented on Camiguin Island, including one bittern, one eagle, one junglefowl, two rails, eight doves and pigeons, one parrot, three cuckoos, one owl, three swiftlets, one dollarbird, two kingfishers, one bee-eater, one hornbill, one pitta, one triller, two bulbuls, one crow, four thrushes, three warblers, six flycatchers, one pipit, one wood swallow, two starlings, three sunbirds, two flowerpeckers, two white-eyes, and two munias. At least seven species reported here are first records for Camiguin. Ten species are widespread Philippine endemics, two are near-endemics, and one (*Loriculus camiguinensis*, described in this volume) is endemic to Camiguin. Additionally, four endemic subspecies are recognized from Camiguin, *Ixos everetti catarmanensis, Hypothymis azurea catarmanensis, Diceum trigonostigma isidroi*, and *Zosterops nigrorum catarmanensis*. While this list is not comprehensive, the presence of 57 species demonstrates that many species were able to cross a narrow but permanent sea channel, and the presence of four endemic subspecies and one endemic species indicates that some genetic differentiation has resulted.

Introduction

Although the avifaunas of many of the Philippine islands have been reported in comprehensive fashion (summarized by Dickinson et al., 1991), no such report has been made for Camiguin Island, with the result that Camiguin has not been included in most analyses of avian biogeography and conservation priorities (e.g., Hauge et al., 1986; Dickinson et al., 1991; Collar et al., 1999; Peterson et al., 2000; but see Mallari et al., 2001, Ong et al., 2002). We note that Camiguin Norte, which lies north of Luzon, is often confused with Camiguin. As documented in the following list, the land birds of Camiguin Island include a diverse assemblage of at least 57 species. These records are based on voucher specimens that were obtained principally during the 1960s and 1990s and are deposited at the Delaware Museum of Natural History (DMNH), the Field Museum of Natural History (FMNH), and Mindanao State University–Iligan Institute of Technology (MSU-IIT), as detailed below and in Chapter 1 (Heaney & Tabaranza, 2006a). Additional records based on specimens at the Museum of Comparative Zoology (MCZ), Cambridge, as cited in Dickinson et al. (1991), are included as well.

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The presence of 55 species of breeding land birds on an island the size of Camiguin in the Philippines is not remarkable; indeed, as documented below, surveys of birds on Camiguin were not exhaustive, and the current total is well below the total number likely to be present. However, given that Camiguin is an oceanic island surrounded by deep water but only about 10 km from the shore of Mindanao, these data are a useful indicator of the ability of these 55 species to readily cross a sea channel of this breadth, given an extensive period of time. Further, as noted below, the avifauna of Camiguin is now considered to include four endemic subspecies of birds (*Ixos everetti catarmanensis, Hypothymis azurea catarmanensis, Diceum trigonostigma isidroi*, and *Zosterops nigrorum catarmanensis*) and an endemic species of parrot (*Loriculus camiguinensis*; Tello et al., 2006). This observation indicates that genetic differentiation has taken place in at least some of these species, leading in one case to significant change. It is our hope that this paper will encourage more extensive and focused analysis of the avifauna of Camiguin, on both ecology and evolution.

For notes on methods of collecting and for a list and description of the collecting sites, see Heaney and Tabaranza (2006a). As noted in that chapter, elevations from the 1960s should be viewed as rough estimates. Species whose names are listed in brackets are of uncertain documentation and are not included in our tally of species numbers. Unverified sight records are listed at the end of this paper. We define "first records" as those not reported by Dickinson et al. (1991) and/or Kennedy et al. (2000).

Accounts of Species

Family Ardeidae—Bitterns, Egrets, and Herons

Ixobrychus cinnamomeus—Cinnamon Bittern

The Cinnamon Bittern ranges from India to China, Ryukyus, Taiwan, and Southeast Asia; in the Philippines it occurs on most islands, except the Babuyan and Batanes group, in marshes, rice fields, and wetlands (Dickinson et al., 1991; Kennedy et al., 2000). A single specimen was taken in a highly disturbed agricultural area in Balbagon, Mambajao, on 28 May 1992, at 10 m, the first record of this species from the island (Site 1).

Specimens Examined—Total 1. Site 1 (1 fmnh).

Family Accipitridae—Hawks and Eagles

Spilornis cheela—Crested Serpent-Eagle

The Crested Serpent-Eagle occurs from India to China, Taiwan, Ryukyus, and Southeast Asia; it is found throughout the Philippines, except the Babuyan and Batanes groups of islands, in forest and forest edge (Dickinson et al., 1991; Kennedy et al., 2000). Two male specimens were taken on 13 June 1968 on Mt. Catarman, one at 2000 ft (ca. 600 m; Site 9), the other at an unknown elevation. We often saw them at nearly all elevations during fieldwork in 1994 and 1995, especially near forest.

Specimens Examined—Total 2. Site 9 (1 dmnh; 1 fmnh).

Family Megapodidae—Megapodes and Scrubfowl

[*Megapodius cumingii*—Tabon]

The Tabon ranges from Sulawesi and Borneo to the Philippines; once widespread throughout the country, it is now found mainly in coastal scrub but also occurs in lowland to montane forest (Dickinson et al., 1991; Kennedy et al., 2000). In an earlier enumeration of Philippine birds, Camiguin was not identified as part of the Tabon's range (Dickinson et al., 1991). However, in the more recent compilation, Kennedy et al. (2000) listed Camiguin as part of the range of this species without further reference to the source of their data. Thus, we have not included *M. cumingii* in our tally of birds from Camiguin but note its potential presence.

Family Phasianidae—Partridges, Pheasants, and Quail

Gallus gallus—Red Junglefowl

The Red Junglefowl occurs from India to southern China and Southeast Asia, including virtually all of the Philippines, except the Batanes group of islands, in forest and forest edge up to 2000 m (Dickinson et al., 1991; Kennedy et al., 2000). A male specimen was taken on Mt. Timpoong at 3150 ft (ca. 950 m) on 14 June 1969 (Site 13). In May 1994, a male specimen was taken in a Victor trap in Kital-is, Sagay at 1200–1400 m (Site 6). We also heard them in March 1995 crowing close to our campsite on Mt. Timpoong at 1275 m (Site 7).

Specimens Examined—Total 2. Site 6 (1 msu-iit); Site 13 (1 dmnh).

Family Rallidae—Coots, Crakes, Rails, and Waterhens

Porzana fusca—Ruddy-breasted Crake

The Ruddy-breasted Crake ranges from India to Japan, Ryukyus, and Southeast Asia; in the Philippines it has been recorded only on the islands of Bohol, Cagayancillo, Leyte, Luzon, Mindanao, Mindoro, Negros, Panay, Samar, and Sibuyan, usually in marshes and rice fields but also along forest paths up to 1500 m (Dickinson et al., 1991; Kennedy et al., 2000). A male specimen was taken in Kasangsangan in the vicinity of Mt. Catarman at 1000 ft (ca. 300 m) on 22 June 1968 (Site 11). This is the first record of this species on Camiguin.

Specimens Examined—Total 1. Site 11 (1 FMNH).

Rallina eurizonoides—Slaty-legged Crake

The Slaty-legged Crake occurs from India and Sri Lanka to Taiwan, Ryukyus, and Southeast Asia. In the Philippines it is rather uncommon on most islands but absent on the Palawan and Sulu groups of islands, in scrub and primary to secondary forest up to 900 m (Dickinson et al., 1991; Kennedy et al., 2000). The record on Camiguin, a first for this island, consists of two specimens, both taken in Victor traps, from Kital-is, Sagay, at 900–1100 m on 19 May 1994 (Site 4) and at 1200–1400 m on 26 May 1994 (Site 6). The following year, another was taken on Mt. Timpoong in primary montane forest at 1275 m on 23 March 1995 (Site 7).

Specimens Examined—Total 3. Site 4 (1 MSU-IIT); Site 6 (1 MSU-IIT); Site 7 (1 FMNH).

Family Columbidae—Doves and Pigeons

Treron vernans—Pink-necked Green-Pigeon

The Pink-necked Green-Pigeon is widespread in Southeast Asia; it has been recorded through most of the Philippines, except the Babuyan and Batanes groups of islands, principally in lowland second-growth forest below 300 m (Dickinson, 1991; Kennedy et al., 2000). An adult male specimen was taken on 29 June 1969 in Puntod, Mahinog, at 800 ft (ca. 250 m).

Specimens Examined—Total 1. Site 14 (1 DMNH).

Phapitreron leucotis—White-eared Brown-Dove

The White-eared Brown-Dove is endemic to the Philippines; it occurs throughout the country with the exception of the Babuyan, Batanes, and Palawan groups of islands, in primary and secondary forest up to about 1600 m (Dickinson et al., 1991; Kennedy et al., 2000). It was recorded from Mt. Catarman and the nearby area of Kasangsangan, at 1000–4500 ft (ca. 300–1400 m) in June 1968 (Sites 9 and 11). Further records were obtained from Mt. Timpoong at 3150–4000 ft (ca. 950–1200 m) and the nearby area of Puntod at 800 ft (ca. 250 m) in June 1969 (Sites 13 and 14, respectively). We also recorded it in May 1994 in Kital-is, Sagay, at 900–1100 m (Site 4).

Specimens Examined—Total 12. Site 4 (1 MSU-IIT); Site 9 (3 DMNH, 1 FMNH); Site 11 (3 FMNH); Site 13 (2 FMNH); Site 14 (2 FMNH).

Ptilinopus occipitalis—Yellow-breasted Fruit-Dove

The Yellow-breasted Fruit-Dove is endemic to the Philippines; it is fairly widespread throughout the country, except the Babuyan, Batanes, Palawan, and Sulu groups of islands, in forest up to 1800 m (Dickinson et al., 1991; Kennedy et al., 2000). It was recorded on Mt. Catarman and the nearby areas of Gidag-on and Kasangsangan at 1000–4500 ft (ca. 300–1400 m) in June 1968 (Sites 9–11). Additional records came from Mt. Timpoong at 3150–4800 ft (ca. 950–1450 m) in June 1969 (Sites 12 and 13).

Specimens Examined—Total 18. Site 9 (3 DMNH, 3 FMNH); Site 10 (1 DMNH, 1 FMNH); Site 11 (1 FMNH); Site 12 (1 FMNH); Site 13 (4 DMNH, 4 FMNH).

Columba vitiensis—Metallic Pigeon

The Metallic Pigeon occurs on Borneo, Sulawesi, Moluccas, Lesser Sunda Islands, New Guinea, and Samoa; it is an uncommon resident of most islands throughout the Philippines, in lowland to mossy forest (Dickinson et al., 1991; Kennedy et al., 2000). Records from Camiguin were all taken in 1968. A female specimen was taken from Mt. Catarman at 2000 ft (ca. 600 m) on 14 June (Site 9) and three adult males and an adult female from Kasangsangan at 1000–2000 ft (ca. 300–600 m) in the vicinity of Mt. Catarman on 11–18 June (Site 11).

Specimens Examined—Total 5. Site 9 (1 FMNH); Site 11 (3 DMNH, 1 FMNH).

Macropygia phasianella—Reddish Cuckoo-Dove

The Reddish Cuckoo-Dove ranges from Borneo, the Moluccas, Sulawesi, and the Lesser Sunda islands to New Guinea and Samoa; it occurs throughout the Philippines, in lowland to mossy forest above 2000 m (Dickinson et al.,

1991; Kennedy et al., 2000). It was recorded on Mt. Catarman and the nearby area of Kasangsangan at 1000–2500 ft (ca. 300–750 m) in June 1968 (Sites 9 and 11). Additional records came from Mt. Timpoong at 3150–5700 ft (ca. 950–1700 m) and the nearby area of Puntod at 800 ft (ca. 250) in June 1969 (Sites 12–14). In May 1994, we recorded it in Kital-is, Sagay, at 1000–1400 m (Sites 5 and 6).

Specimens Examined—Total 30. Site 5 (1 msu-iit); Site 6 (2 msu-iit); Site 9 (1 fmnh); Site 11 (3 dmnh, 3 fmnh); Site 12 (9 dmnh, 7 fmnh); Site 13 (1 dmnh, 2 fmnh); Site 14 (1 fmnh).

Streptopelia bitorquata—Island Collared-Dove

The Island Collared-Dove is found from Borneo and the Lesser Sunda islands to Java; in the Philippines it is a fairly uncommon resident of most islands, except the Batanes group of islands, mainly in relatively open fields in the lowlands and sometimes in mangrove (Dickinson et al., 1991; Kennedy et al., 2000). Two male specimens were collected from Puntod, Mahinog, at 700–800 ft (ca. 200–250 m), one of which was a juvenile taken at 800 ft (ca. 250 m) on 28 June 1968 (Site 14).

Specimens Examined—Total 2. Site 14 (1 dmnh, 1 fmnh).

Geopelia striata—Zebra Dove

The Zebra Dove ranges from Southeast Asia to Australia; it occurs throughout the Philippines, except the Babuyan and Batanes groups of islands, in open country and cultivated areas in the lowlands (Dickinson et al., 1991; Kennedy et al., 2000). One of us (B.R.T.) netted one some 50 m away from the beach in Manuyog, Sagay, on 10 May 1994 (Site 3), but it was released. No other specimen was recorded of this species in 1994. It was not recorded during our fieldwork in 1992 and 1995.

Specimens Examined—None.

Chalcophaps indica—Common Emerald-Dove

The Common Emerald-Dove is found from India and Sri Lanka to China, Taiwan, Ryukyus and Southeast Asia, New Guinea, and Australia; it occurs throughout the Philippines, often in second-growth forest in the lowlands up to 1000 m (Dickinson et al., 1991; Kennedy et al., 2000). Records on Camiguin consist of specimens taken in Kasangsangan, near Mt. Catarman, at 1000–2500 ft (ca. 300–750 m) in June 1968 (Site 11) and from Puntod at 800 ft (ca. 250 m) in May 1969 (Site 14).

Specimens Examined—Total 5. Site 11 (2 dmnh, 2 fmnh); Site 14 (1 fmnh).

Family Psittacidae—Lorikeets, Cockatoos, Parrots, and Racquet-tails

Loriculus camiguinensis—Camiguin Hanging-Parrot

Described as a new species in this volume (Tello et al., 2006), this is the only species of bird currently recognized as endemic to Camiguin. Its elevational range, based on specimens collected in the 1960s, is 300 to 1350, thus including lowland and montane rain forest. Most of this habitat has been destroyed on Camiguin, leading to concern for its conservation status.

Specimens Examined—Total 23. Site 9 (2 dmnh); Site 11 (5 dmnh, 5 fmnh); Site 13 (5 dmnh, 6 fmnh).

Family Cuculidae—Cuckoos, Malkohas, and Coucals

Cacomantis variolosus—Brush Cuckoo

The Brush Cuckoo occurs from Southeast Asia to Australia and the Southwest Pacific; it is found throughout the Philippines, except the Babuyan and Batanes groups of islands, from mangrove to mossy forest at 2000 m (Dickinson et al., 1991; Kennedy et al., 2000). The records from Camiguin were taken from Mt. Catarman at 2500 ft (ca. 750 m) in June 1968 (Site 9) and from Mt. Timpoong at 3150–4800 ft (ca. 950–1450 m) in June 1969 (Site 13). We also recorded it in Kital-is, Sagay, at 900–1100 (Site 4) and 1200–1400 m in May 1994 (Site 6).

Specimens Examined—Total 7. Site 6 (1 msu-iit); Site 9 (1 fmnh); Site 13 (3 dmnh, 2 fmnh).

Eudynamys scolopacea—Common Koel

The Common Koel occurs from India through Southeast Asia to northern Australia; it is found throughout the Philippines, in primary and secondary lowland forest (Dickinson et al., 1991; Kennedy et al., 2000). The single specimen from Camiguin was taken on Mt. Timpoong at 3150 ft (ca. 950 m) on 17 June 1969 (Site 13).

Specimens Examined—Total 1. Site 13 (1 fmnh).

Centropus viridis—Philippine Coucal

The Philippine Coucal is endemic to the Philippines, where it occurs throughout the country, except the Palawan group of islands, from grassland to forest at 2000 m (Dickinson et al., 1991; Kennedy et al., 2000). The records on Camiguin consist of specimens taken from

Kasangsangan in the vicinity of Mt. Catarman at 1000–1500 ft (ca. 300–450 m) in June 1968 (Site 11) and from Mt. Timpoong at 3150 ft (ca. 950 m) in June 1969 (Site 13).

SPECIMENS EXAMINED—Total 6. Site 11 (1 DMNH, 2 FMNH); Site 13 (1 DMNH, 2 FMNH).

Family Strigidae—Owls

Ninox philippensis—Philippine Hawk-Owl

The Philippine Hawk-Owl is endemic to the Philippines, occurring throughout most of the islands, except the Babuyan, Batanes, and Palawan groups, in the lowlands up to 1800 m (Dickinson et al., 1991; Kennedy et al., 2000). The records from Camiguin consist of a female taken from Mt. Catarman at 1500 ft (ca. 450 m) on 17 June 1968 (Site 9) and another female from Mt. Timpoong on 13 June 1969 at an unknown elevation. Specimens of other species from Mt. Timpoong on the same date were taken at 3150 ft (ca. 950 m).

SPECIMENS EXAMINED—Total 2. Site 9 (1 FMNH); Site 13 (1 FMNH).

Family Apodidae—Swifts

Collocalia mearnsi—Philippine Swiftlet

The Philippine Swiftlet is endemic to the Philippines, where it is recorded mainly on the islands of Bohol, Cebu, Luzon, Mindanao, Mindoro, Negros, Palawan, and Panay, usually in forest and forest clearings above 900 m; it is absent from the Babuyan, Batanes, and Sulu groups of islands (Dickinson et al., 1991; Kennedy et al., 2000). Specimens from Camiguin were taken from Mt. Catarman and in the nearby Kasangsangan at 1000–2000 ft (ca. 300–600 m) on 16 June 1968 (Sites 9 and 11) and from Mt. Timpoong on 23 June 1969 from an unknown elevation. Specimens of other species from this site were taken at 3100–3350 ft (ca. 950–1000 m), with several at 4000 ft (ca. 1200 m).

SPECIMENS EXAMINED—Total 4. Site 9 (1 FMNH); Site 11 (1 FMNH); Site 13 (2 FMNH).

Collocalia esculenta—Glossy Swiftlet

The Glossy Swiftlet occurs from the Andamans, Nicobars, and Malay Peninsula to New Guinea and the southwest Pacific; it is found throughout the Philippines, from sea level to mountaintops (Dickinson et al., 1991; Kennedy et al., 2000). It was commonly recorded on Mt. Catarman and in the nearby area of Kasangsangan at 1000–2000 ft (ca. 300–600 m) in June 1968 (Sites 9 and 11) and on Mt. Timpoong at 3150–4800 ft (ca. 950–1450 m) in June 1969 (Sites 12 and 13).

SPECIMENS EXAMINED—Total 31. Site 9 (1 FMNH); Site 11 (2 DMNH, 7 FMNH); Site 12 (2 DMNH, 1 FMNH); Site 13 (9 DMNH, 9 FMNH).

Collocalia troglodytes—Pygmy Swiftlet

The Pygmy Swiftlet is endemic to the Philippines, where it occurs throughout most of the country, except the Babuyan, Batanes, and Sulu groups of islands, usually at low to middle elevations in forested areas (Dickinson et al., 1991; Kennedy et al., 2000). The records from Camiguin were taken on 13 and 21 June 1968 in Kasansangan at 1500–2000 ft (ca. 450–600 m) and on Mt. Timpoong at 3150 ft (ca. 950 m) on 25 June 1969 (Site 13).

SPECIMENS EXAMINED—Total 4. Site 11 (3 DMNH); Site 13 (1 FMNH).

Family Coraciidae—Rollers

Eurystomus orientalis—Dollarbird

The Dollarbird occurs from India to New Guinea and the southwest Pacific, including all of the Philippines, except the Batanes group of islands, in forest edge and clearings in the lowlands up to 1200 m (Dickinson et al., 1991; Kennedy et al., 2000). Dickinson et al. (1991) noted a single specimen deposited in the Museum of Comparative Zoology, Harvard University, taken from Mambajao on 19 August 1921; no elevation was indicated.

SPECIMENS EXAMINED—None.

Family Alcedinidae—Kingfishers

Ceyx lepidus—Variable Dwarf-Kingfisher

The Variable Dwarf-Kingfisher occurs from the Moluccas to New Guinea and the southwest Pacific islands; in the Philippines it is recorded on the islands in the Central Philippines as well as on the Mindanao and Sulu groups of islands, in primary and secondary lowland forest (Dickinson et al., 1991; Kennedy et al., 2000). It was recorded from Mt. Timpoong at 3150 ft (ca. 950 m) on 17 and 18 June 1969 (Site 13). In May 1994, two individuals were recorded in Kital-is, Sagay, at 900–1100 m (Site 4), including one that was taken in a Victor trap on 17 May.

SPECIMENS EXAMINED—Total 4. Site 4 (2 MSU-IIT); Site 13 (1 DMNH, 1 FMNH).

Halcyon chloris—White-collared Kingfisher

The White-collared Kingfisher occurs widely from northeast Africa to southern China, Ryukyus, Southeast Asia to New Guinea, Australia, and the southwest Pacific; it is found nearly all over the Philippines, from exposed reefs to open country and forest edge (Dickinson et al., 1991; Kennedy et al., 2000). It was recorded in Gidag-on and Kasangsangan, both in the vicinity of Mt. Catarman, at 500–2500 ft (ca. 150–600 m; Sites 10 and 11) in June 1968 and on Mt. Timpoong at 3150 ft (ca. 950 m; Site 13), in Puntod at 800 ft (ca. 250 m; Site 14), and Mantigue Island (Site 19) in June 1969. We recorded it further in Balbagon, Mambajao, at 10 m in May 1992 (Site 1). On 10 May 1994, we also recorded it in Manuyog, Sagay, at 80 m (Site 3).

Specimens Examined—Total 33. Site 1 (1 FMNH); Site 10 (6 DMNH, 4 FMNH); Site 11 (1 DMNH, 1 FMNH); Site 13 (5 DMNH, 5 FMNH); Site 14 (4 DMNH, 5 FMNH); Site 19 (1 DMNH).

Family Meropidae—Bee-Eaters

Merops viridis—Blue-throated Bee-eater

The Blue-throated Bee-eater occurs in Southeast Asia and the Philippines, where it is known from many islands, except the Babuyan, Batanes, Palawan, and Sulu groups; it often found in open country, scrubs, and forest clearings (Dickinson et al., 1991; Kennedy et al., 2000). On Camiguin, it was recorded from Mt. Catarman and in nearby Kasangsangan at 1000–4500 m (ca. 300–1400 m) in June 1968 (Sites 9 and 11) and on Mt. Timpoong at 3350 ft (ca. 1000 m) in June 1969 (Site 13).

Specimens Examined—Total 9. Site 9 (1 DMNH, 2 FMNH); Site 11 (2 DMNH, 2 FMNH); Site 13 (1 DMNH, 1 FMNH).

Family Bucerotidae—Hornbills

Aceros leucocephalus—Writhed Hornbill

The Writhed Hornbill is endemic to Mindanao, Dinagat, and Camiguin, in forest up to 1200 m (Dickinson et al., 1991; Kennedy et al., 2000). The records from Camiguin in 1968 consist of a male taken from Kasangsangan in the vicinity of Mt. Catarman at 1000 ft (ca. 300 m) on June 16 (Site 11) and another male from Mt. Catarman at 2000–4000 ft (ca. 600–1200 m) on June 17 (Site 9). A female was also obtained from Mt. Timpoong at 3150 ft (ca. 950 m) on 16 June 1969 (Site 13). We did not record it during our fieldwork in the 1990s. Mallari et al. (2001) mention, without further reference to the source, a juvenile captured in Ginsiliban in 1993. The most recent evaluation of this species found it to be fairly common despite "losing ground clearly to habitat clearance, hunting and trapping for trade" and assigned it a Near-Threatened status (Collar et al., 1999).

Specimens Examined—Total 3. Site 9 (1 DMNH); Site 11 (1 FMNH); Site 13 (1 FMNH).

Family Pittidae—Pittas

Pitta erythrogaster—Red-bellied Pitta

The Red-bellied Pitta occurs from Sulawesi to the Moluccas and New Guinea and northeast Australia; it is found throughout the Philippines, except the Batanes group of islands, in primary and secondary forest usually below 1000 m (Dickinson et al., 1991; Kennedy et al., 2000). Three individuals, a male and two females, were taken from Mt. Timpoong at 3150–5700 ft (ca. 950–1700 m) on 14–25 June 1969 (Sites 12 and 13). We recorded it further on the same mountain at 1475 m on 22 March 1995 (Site 8). In May 1994, it was the most common bird taken in Victor traps in Kital-is, Sagay, at 900–1100 m to 1200–1400 m (Sites 4–6).

Specimens Examined—Total 9. Site 4 (2 MSU-IIT); Site 5 (1 MSU-IIT); Site 6 (2 MSU-IIT); Site 8 (1 FMNH); Site 12 (1 DMNH); Site 13 (2 FMNH).

Family Campephagidae—Cuckoo-Shrikes, Minivets, and Trillers

Lalage nigra—Pied Triller

The Pied Triller ranges from the Nicobars to Southeast Asia; it occurs throughout the Philippines, except the Batanes and Babuyan groups of islands, usually in open areas in the lowlands up to 1400 m (Dickinson et al., 1991; Kennedy et al., 2000). It was recorded from Gidag-on and Kasangsangan in the vicinity of Mt. Catarman at 500–2000 ft (ca. 150–600 m) in June 1968 (Sites 10 and 11). In June of the following year, records came mainly from Mt. Timpoong at 3150 ft (ca. 950 m; Site 13), Puntod, at 800 ft (ca. 150 m; Site 14), and Mantigue Island (Site 19).

Specimens Examined—Total 30. Site 10 (9 DMNH, 4 FMNH); Site 11 (2 FMNH); Site 13 (1 DMNH); Site 14 (4 DMNH, 5 FMNH); Site 19 (5 DMNH).

Family Pycnonotidae—Bulbuls

Pycnonotus goiavier—Yellow-vented Bulbul

The Yellow-vented Bulbul occurs widely in Southeast Asia and throughout the Philippines,

except the Babuyan and Batanes groups of islands, in scrub and second-growth forest (Dickinson et al., 1991; Kennedy et al., 2000). It was recorded from Mt. Catarman and its nearby areas of Gidag-on and Kasangsangan at 500–4000 ft (ca. 150–1200 m) in June 1968 (Sites 9–11). In June 1969, additional records were obtained from Mt. Timpoong at 3150–4800 ft (ca. 950–1450 m; Sites 12 and 13) and the nearby area of Puntod at 800 ft (ca. 250 m; Site 14) as well as from Mantigue Island on 28 June (Site 19). We recorded it further in Balbagon, Mambajao, at 10 m on 28 May 1992 (Site 1). Dickinson et al. (1991) noted the presence of another specimen from an unspecified locality on Camiguin, deposited at the Museum of Comparative Zoology, Harvard University.

Specimens Examined—Total 30. Site 1 (1 FMNH); Site 9 (1 DMNH, 1 FMNH); Site 10 (5 DMNH, 5 FMNH); Site 11 (2 DMNH, 3 FMNH); Site 12 (1 DMNH); Site 13 (5 FMNH); Site 14 (2 DMNH, 3 FMNH); Site 19 (1 DMNH).

Ixos everetti—Yellowish Bulbul

The Yellowish Bulbul is endemic to the islands of Biliran, Bucas Grande, Dinagat, Leyte, Mindanao, Panaon, Samar, and Siargao, the Sulu group, and Camiguin, usually in primary and secondary lowland forest (Dickinson et al., 1991; Kennedy et al., 2000). Three subspecies are recognized, including *I. e. catarmanensis*, which is restricted to Camiguin (Rand & Rabor, 1969). Our comparison of specimens at FMNH with those of other named subspecies supports the distinctiveness of the Camiguin population; it is substantially the largest and darkest among the three races that are currently recognized (Dickinson et al., 1991; Kennedy et al., 2000). The call of this species is equally distinct (Kennedy et al., 2000). The geographic variation observed in this species as currently defined is unusually great and is suggestive of a potential species group. Further taxonomic studies are warranted.

This species was recorded in June 1968 from Mt. Catarman and the nearby areas of Gidag-on and Kasangsangan at 500–4500 ft (ca. 150–1400 m; Sites 9–11). Additional records were obtained in June 1969 from Mt. Timpoong at 3150–5700 ft (ca. 950–1700 m; Sites 12 and 13) and the nearby area of Puntod at 800 ft (ca. 250 m; Site 14). In May 1994, it was one of the most common birds mist netted in Kital-is, Sagay, at 900–1100 m to 1200–1400 m (Sites 4–6).

Specimens Examined—Total 94. Site 4 (8 MSU-IIT); Site 5 (2 MSU-IIT); Site 6 (1 MSU-IIT); Site 9 (6 DMNH, 15 FMNH); Site 10 (6 DMNH); Site 11 (9 DMNH, 7 FMNH); Site 12 (2 DMNH, 2 FMNH); Site 13 (20 DMNH, 13 FMNH); Site 14 (2 DMNH, 1 FMNH).

Family Corvidae—Crows

Corvus macrorhynchos—Large-Billed Crow

The Large-Billed Crow occurs from Iran to Northeast Asia, China, Taiwan, Ryukyus, and Southeast Asia; it is found nearly throughout the Philippines, in forest edge to plantations and in towns (Dickinson et al., 1991; Kennedy et al., 2000). A male specimen was taken from Gidag-on in the vicinity of Mt. Catarman at 1000 ft (ca. 300 m) on 24 June 1968 (Site 10).

Specimens Examined—Total 1. Site 10 (1 FMNH).

Family Turdidae—Robins, Shamas, and Thrushes

Copsychus saularis—Oriental Magpie-Robin

The Oriental Magpie-Robin occurs from Pakistan and India to southern China and Southeast Asia; in the Philippines, it occurs throughout the country, except the Palawan, Babuyan, and Batanes groups of islands, usually in second-growth and scrubby forest (Dickinson et al., 1991; Kennedy et al., 2000). It was recorded from Mt. Catarman and in the nearby area of Gidag-on at 500–3000 ft (ca. 150–900 m) in June 1968 (Sites 9 and 10). Additional records were obtained in June 1969 from Mt. Timpoong at 4000 ft (1200 m; Site 13) and the nearby area of Puntod at 800 ft (ca. 250 m; Site 14). We recorded it further in May 1994 in Kital-is, Sagay, at 900–1100 m (Site 4) and 1200–1400 m (Site 6).

Specimens Examined—Total 16. Site 4 (3 MSU-IIT); Site 6 (1 MSU-IIT); Site 9 (1 FMNH); Site 10 (4 DMNH, 3 FMNH); Site 13 (3 FMNH); Site 14 (1 FMNH).

Saxicola caprata—Pied Bushchat

The Pied Bushchat occurs from Iran to southwest China, Southeast Asia, and New Guinea; it is a common resident in the Philippines, except the Sulu, Palawan, Babuyan, and Batanes groups of islands, usually in fairly dry, open country (Dickinson et al., 1991; Kennedy et al., 2000). A female specimen was taken from Mt. Catarman at 2000 ft (ca. 600 m) on 19 June 1968 (Site 9).

Specimens Examined—Total 1. Site 9 (1 FMNH).

Zoothera andromedae—Sunda Ground-Thrush

The Sunda Ground-Thrush occurs from Java and Sumatra to the Lesser Sunda Islands; it is an uncommon resident in the Philippines, where it has been recorded mainly on mountains in the northern and central Luzon, Mindanao, Mindoro, Negros, and Panay, in the understory of forest above 1000 m (Dickinson et al., 1991; Kennedy et al., 2000). We recorded a single specimen, taken in a Victor rat trap, from Mt. Timpoong at 1275 m on 23 March 1995 (Site 7); this is the first record for Camiguin.

Specimens Examined—Total 1. Site 7 (1 FMNH).

Zoothera dauma—Scaly Ground-Thrush

The Scaly Ground-Thrush is an uncommon winter visitor to the Philippines from Siberia, India, China, Japan, Korea, and Taiwan. It has been recorded previously only on the islands of Batan, Catanduanes, Fuga, Luzon, Marinduque, Mindoro, Palawan, and Sibuyan, where it forages on the ground and forest understory at all elevations (Dickinson et al., 1991; Kennedy et al., 2000). Our record on Camiguin consists of a single specimen taken in a Victor rat trap on Mt. Timpoong at 1275 m on 19 March 1995 (Site 7). This is the first record of this species for the island.

Specimens Examined—Total 1. Site 7 (1 FMNH).

Family Sylviidae—Old World Warblers

Phylloscopus trivirgatus—Mountain Leaf-Warbler

The Mountain Leaf-Warbler occurs from the Malay Peninsula, Borneo, Sumatra, Java, and the Lesser Sunda Islands to New Guinea; in the Philippines it is found mainly on the islands of Luzon, Mindanao, Negros, Palawan, and Panay, in montane and mossy forest above 800 m (Dickinson et al., 1991; Kennedy et al., 2000). An endemic subspecies, *P. t. diuatae*, is recognized on Camiguin and Mt. Hilong-hilong (eastern Mindanao; Dickinson et al., 1991; Kennedy et al., 2000), though Dickinson (in litt.) considered this in need of reassessment. Records on Camiguin were obtained from Mt. Catarman at 2000–4950 ft (ca. 600–1500 m) in June 1968 (Site 9) and from Mt. Timpoong at 4800–5700 ft (ca. 1450–1700 m) in June 1969 (Sites 12 and 13). It was also recorded in Kital-is, Sagay, at 900–1100 m in May 1994 (Site 4).

Specimens Examined—Total 31. Site 4 (1 MSU-IIT); Site 9 (3 DMNH, 5 FMNH); Site 12 (10 DMNH, 10 FMNH); Site 13 (2 DMNH).

Megalurus timoriensis—Tawny Grassbird

The Tawny Grassbird occurs from the Lesser Sunda Islands, Moluccas, and Sulawesi to New Guinea and Australia; it is found throughout most of the Philippines, excluding the Babuyan, Batanes, Palawan, and Sulu groups of islands, in grasslands and disturbed forest up to 2000 m (Dickinson et al., 1991; Kennedy et al., 2000). It was recorded in 1968 from Kasangsangan in the vicinity of Mt. Catarman at 1000 ft (ca. 300 m) on June 20 (Site 11). Additional records were obtained from Mt. Timpoong at 3250 ft (ca. 980 m) in June 1969 (Site 13). We also recorded it in May 1994 in Kital-is, Sagay, at 1000–1300 m (Site 5).

Specimens Examined—Total 10. Site 5 (1 MSU-IIT); Site 11 (2 FMNH); Site 13 (3 DMNH, 4 FMNH).

Cisticola exilis—Bright-capped Cisticola

The Bright-capped Cisticola ranges from India to southern China, Taiwan, Southeast Asia (excluding the Malay Peninsula) to New Guinea, Australia, and the southwest Pacific; it occurs on most islands of the Philippines, excluding the Babuyan, Batanes, Palawan, and Sulu groups of islands, in grassy habitats and rice fields (Dickinson et al., 1991; Kennedy et al., 2000). Two adult males were taken in 1968, one from Mt. Catarman at 2000 ft (ca. 600 m) on 19 June (Site 9) and the other from Kasangsangan in the vicinity of Mt. Catarman at 1500 ft (ca. 450 m) on 21 June (Site 11).

Specimens Examined—Total 2. Site 9 (1 DMNH); Site 11 (1 FMNH).

Family Muscicapidae—Flycatchers

Ficedula hyperythra—Snowy-browed Flycatcher

The Snowy-browed Flycatcher ranges from the Himalayas to southern China, Taiwan, and Southeast Asia; it occurs on most of the larger islands throughout the Philippines, in dense forest understory usually above 1000 m, but is absent on Sibuyan and the Batanes and Sulu groups of islands (Dickinson et al., 1991; Kennedy et al., 2000). On Camiguin, we recorded this species for the first time in Kital-is, Sagay, at 900–1100 m in May 1994 (Site 4) and on Mt. Timpoong at 1275 m on 25 March 1995 (Site 7).

SPECIMENS EXAMINED—Total 5. Site 4 (4 MSU-IIT); Site 7 (1 FMNH).

Ficedula westermanni—Little Pied Flycatcher

The Little Pied Flycatcher occurs from India to southern China and Southeast Asia; in the Philippines, it has been recorded only from Luzon, Mindanao, Mindoro, Negros, southern Palawan, and Panay, in forest and forest edge above 800 m, usually in middle story and forest canopy (Dickinson et al., 1991; Kennedy et al., 2000). The records from Camiguin were taken from Mt. Catarman at 2000–4950 ft (ca. 600–1500 m) in June 1968 (Site 9) and on Mt. Timpoong at 3150–5700 ft (ca. 950–1700 m) in June 1969 (Sites 12 and 13). On 29 May 1992, we recorded it on Mt. Mambajao at 1000 m (Site 2) and in May 1994 in Kital-is, Sagay, at 900–1300 m (Sites 4 and 5).

SPECIMENS EXAMINED—Total 42. Site 2 (1 FMNH); Site 4 (3 MSU-IIT); Site 5 (1 MSU-IIT); Site 9 (12 DMNH, 10 FMNH); Site 12 (9 DMNH, 4 FMNH); Site 13 (2 FMNH).

Cyornis rufigastra—Mangrove Blue Flycatcher

The Mangrove Blue Flycatcher ranges from the Malay Peninsula, Java, Sumatra, and Sulawesi to Borneo and the Philippines; it occurs throughout most of the islands of the Philippines, except the Batanes group, usually in disturbed forest habitat (Dickinson et al., 1991; Kennedy et al., 2000). It was recorded from Mt. Catarman and the nearby areas of Gidag-on and Kasangsangan at 500–4950 ft (ca. 150–1500 m) in June 1968 (Sites 9–11). Further records were obtained from Mt. Timpoong at 3150–4800 ft (ca. 950–1450 m; Sites 12 and 13) and the nearby area of Puntod at 800 ft (ca. 250 m; Site 14) in June 1969. We also recorded it in Kital-is, Sagay, at 900–1100 m in May 1994 (Site 4).

SPECIMENS EXAMINED—Total 70. Site 4 (4 MSU-IIT); Site 9 (8 DMNH, 9 FMNH); Site 10 (7 DMNH, 4 FMNH); Site 11 (6 DMNH, 6 FMNH); Site 12 (2 DMNH, 4 FMNH); Site 13 (7 DMNH, 5 FMNH); Site 14 (4 DMNH, 4 FMNH).

Rhipidura javanica—Pied Fantail

The Pied Fantail ranges from the Malay Peninsula, Sumatra, and Java to Borneo and the Philippines, where it occurs throughout most of the islands, except the Babuyan and Batanes groups, usually in lowland second growth, residential areas, bamboo thickets, and mangroves (Dickinson et al., 1991; Kennedy et al., 2000). It was recorded mainly from the lower slopes of Mt. Catarman and the nearby areas of Gidag-on and Kasangsangan in June 1968 at 500–2000 ft (ca. 150–600 m; Sites 9–11). Additional records in June 1969 were taken from Mt. Timpoong, at 3150 ft (ca. 950 m; Site 13) and the nearby area of Puntod at 800 ft (ca. 250 m; Site 14). We also recorded it in May 1994 in Kital-is, Sagay, at 1000–1400 m (Sites 5 and 6).

SPECIMENS EXAMINED—Total 32. Site 5 (2 MSU-IIT); Site 6 (1 MSU-IIT); Site 9 (2 FMNH); Site 10 (7 DMNH, 7 FMNH); Site 11 (3 DMNH, 3 FMNH); Site 13 (1 DMNH, 2 FMNH); Site 14 (2 DMNH, 2 FMNH).

Terpsiphone cinnamomea—Rufous Paradise-Flycatcher

The Rufous Paradise-Flycatcher occurs throughout the Philippines, excluding the Babuyan, Batanes, and Palawan groups of islands, in understory of forest up to 1200 m; it also occurs on several of the Talaud Islands, Indonesia (Dickinson et al., 1991; Kennedy et al., 2000). Three specimens, two females and a male, were taken on 16–23 June 1969 from Mt. Timpoong at 1500–3150 ft (ca. 450–950 m; Site 13); another female was recorded from Puntod at 800 ft (ca. 250 m) on 27 June 1969 (Site 14). In May 1994, it was recorded in Kital-is, Sagay, at 900–1100 m (Site 4).

SPECIMENS EXAMINED—Total 5. Site 4 (1 MSU-IIT); Site 13 (1 DMNH, 2 FMNH); Site 14 (1 DMNH).

Hypothymis azurea—Black-naped Monarch

The Black-naped Monarch ranges from India to southern China and Taiwan to Southeast Asia; it occurs nearly throughout the Philippines, except the Batanes group of islands, usually in disturbed forest and forest edge below 1500 m (Dickinson et al., 1991; Kennedy et al., 2000). The population on Camiguin is recognized as a distinct endemic subspecies, *H. a. catarmanensis* (Rand & Rabor, 1969). Records from Camiguin in June 1968 came from Mt. Catarman and the nearby areas of Gidag-on and Kasangsangan at 1000–4950 ft (ca. 300–1450 m). Further records in June 1969 came from both Mt. Catarman at 2000–4950 ft (ca. 600–1450 m; Sites 9–11) and Mt. Timpoong at 3150 ft (ca. 950 m; Site 13). In May 1994, we recorded it in Kital-is, Sagay, at 900–1100 m to 1200–1400 m (Sites 4–6).

SPECIMENS EXAMINED—Total 33. Site 4 (2 MSU-IIT), Site 5 (1 MSU-IIT); Site 6 (2 MSU-IIT); Site 9 (3

DMNH, 4 FMNH); Site 10 (1 DMNH, 1 FMNH); Site 11 (2 DMNH, 3 FMNH); Site 13 (12 DMNH, 2 FMNH).

Family Motacillidae—Pipits, Wagtails

Anthus hodgsoni—Olive Tree-Pipit

The Olive Tree-Pipit is an uncommon migrant from eastern Asia to India, southern China, Taiwan, Ryukyus, and Southeast Asia; in the Philippines it has been recorded on many of the larger islands, except the Batanes and Sulu groups, usually in pine and oak forest above 300 m (Dickinson et al., 1991; Kennedy et al., 2000). On Camiguin, we recorded this species in primary montane forest on Mt. Timpoong at 1275 m on 24 March 1995 (Site 7); it is the first record from Camiguin.

SPECIMENS EXAMINED—Total 1. Site 7 (1 FMNH).

Family Artamidae—Wood Swallows

Artamus leucorynchus—White-breasted Wood-Swallow

The White-breasted Wood-Swallow occurs from Borneo, Sulawesi, to New Guinea, Australia, and the southwest Pacific; it occurs throughout the Philippines, except the Babuyan and Batanes groups of islands, usually at forest edge or in disturbed forest up to 1800 m (Dickinson et al., 1991; Kennedy et al., 2000). Records from Camiguin in June 1968 came from Mt. Catarman and the nearby areas of Gidag-on and Kasangsangan at 500–2000 ft (ca. 150–600 m; Sites 9 and 10). Additional records in June 1969 were from Mt. Timpoong at 3150 ft (ca. 950 m; Site 13) and Puntod at 800 ft (ca. 250 m; Site 14).

SPECIMENS EXAMINED—Total 19. Site 9 (1 DMNH, 1 FMNH); Site 10 (5 DMNH; 4 FMNH); Site 11 (1 DMNH); Site 13 (2 DMNH; 4 FMNH); Site 14 (1 DMNH).

Family Sturnidae—Mynas and Starlings

Aplonis panayensis—Asian Glossy Starling

The Asian Glossy Starling is found from eastern India to Southeast Asia; it occurs throughout the Philippines, in agricultural and residential areas and forest edge in the lowlands (Dickinson et al., 1991; Kennedy et al., 2000). Records from Camiguin in June 1968 came from the lower slopes of Mt. Catarman and nearby areas of Gidag-on and Kasangsangan at 500–2000 ft (ca. 150–600 m; Sites 10 and 11). Two other specimens were obtained in Puntod at 800 ft. (ca. 250 m) in June 1969 (Site 14). We recorded it further in Balbagon, Mambajao, on 28 May 1992 at 10 m (Site 1).

SPECIMENS EXAMINED—Total 40. Site 1 (1 FMNH); Site 10 (15 DMNH, 21 FMNH); Site 11 (1 DMNH); Site 14 (2 DMNH).

Sarcops calvus—Coleto

The Coleto occurs almost exclusively in the Philippines, in agricultural plantations, second growth, and forest edge in the lowlands; its only record outside the country is on Banggi Island, off Borneo (Dickinson et al., 1991; Kennedy et al., 2000). Within the Philippines itself, however, it is absent from the Babuyan, Batanes, and Palawan groups of islands (Dickinson et al., 1991; Kennedy et al., 2000). In June 1968, two specimens each were taken from Gidag-on at 500–1500 ft (ca. 150–450 m; Site 10) and Kasangsangan at 1000 ft (ca. 300 m; Site 11), both in the vicinity of Mt. Catarman.

SPECIMENS EXAMINED—Total 4. Site 10 (2 DMNH); Site 11 (2 FMNH).

Family Nectariniidae—Spiderhunters and Sunbirds

Anthreptes malacensis—Plain-throated Sunbird

The Plain-throated Sunbird occurs throughout most of Southeast Asia; in the Philippines, it is found on almost all islands, except the Babuyan and Batanes groups, in coconut groves, mangroves, and second-growth forest in the lowlands (Dickinson et al., 1991; Kennedy et al., 2000). Records on Camiguin came mainly from Kasangsangan in the vicinity of Catarman Mountain at 1500–2000 ft (ca. 450–600 m) in June 1968 (Site 11) and Puntod at 800 ft (ca. 250 m) in June 1969 (Site 14). A single specimen was taken on Mt. Timpoong at an unknown elevation on 16 June 1969. Specimens of other species from the same site and date were taken at 1500–3150 ft (ca. 450–950 m).

SPECIMENS EXAMINED—Total 12. Site 11 (3 DMNH, 3 FMNH); Site 13 (1 DMNH); Site 14 (5 DMNH).

Nectarinia jugularis—Olive-backed Sunbird

The Olive-backed Sunbird occurs from Southeast Asia to New Guinea, Australia, and the southwest Pacific; in the Philippines, it occurs on almost all islands, except the Babuyan and Batanes groups, usually in heavily disturbed habitats, including towns and cities, below 1000 m (Dickinson et al., 1991; Kennedy et al., 2000). Records from Camiguin were obtained from Mt. Catarman and the nearby areas of

Gidag-on and Kasangsangan at 500–3000 ft (ca. 150–900 m) in June 1968 (Sites 10 and 11). In June 1969, additional records came from Mt. Timpoong at 1000–5000 ft (ca. 300–1500 m; Sites 12 and 13) and the nearby area of Puntod at 800 ft (ca. 250 m; Site 14) as well as from the island of Mantigue (Site 19). We recorded it further in Balbagon, Mambajao, on 28 May 1992 at 10 m (Site 1) and in Kital-is, Sagay, at 1000–1300 m in May 1994 (Site 5).

Specimens Examined—Total 94. Site 1 (2 FMNH); Site 5 (1 MSU-IIT); Site 10 (24 DMNH, 20 FMNH); Site 11 (4 DMNH, 6 FMNH); Site 12 (5 DMNH, 3 FMNH); Site 13 (1 FMNH); Site 14 (14 DMNH, 6 FMNH); Site 19 (8 DMNH).

Nectarinia sperata—Purple-throated Sunbird

The Purple-throated Sunbird occurs from India and Southeast Asia; it is found throughout the Philippines, except the Batanes group of islands, in cultivated areas, mangroves, and secondary forest in the lowlands (Dickinson et al., 1991; Kennedy et al., 2000). Records from Camiguin in June 1968 were obtained from Mt. Catarman and the nearby areas of Gidag-on and Kasangsangan at 500–3000 ft (ca. 150–900 m; Sites 9–11). In June the following year, records were obtained from Mt. Timpoong at 3150 ft (ca. 950 m; Site 13) and in the nearby area of Puntod at 800 ft (ca. 250 m; Site 14). Additionally, Dickinson et al. (1991) noted two specimens from an unspecified locality and elevation on Camiguin that are deposited at the Museum of Comparative Zoology, Harvard University.

Specimens Examined—Total 39. Site 9 (3 DMNH, 3 FMNH); Site 10 (6 DMNH, 6 FMNH); Site 11 (3 DMNH, 7 FMNH); Site 13 (7 FMNH); Site 14 (1 DMNH, 3 FMNH).

Family Dicaeidae—Flowerpeckers

Dicaeum trigonostigma—Orange-bellied Flowerpecker

The Orange-bellied Flowerpecker ranges eastern India to Southeast Asia; it occurs throughout the Philippines, except on the Babuyan and Batanes groups of islands, in forest edge, second growth, and cultivated areas below 1500 m (Dickinson et al., 1991; Kennedy et al., 2000). On Camiguin, this species is represented by an endemic subspecies, *D. t. isidroi* (Rand & Rabor, 1969). Records from Camiguin were obtained from Mt. Catarman and the nearby areas of Gidag-on and Kasangsangan at 500–4500 ft (ca. 150–1400 m) in June 1968 (Sites 9–11). Additional records in June 1969 were obtained from Mt. Timpoong at 800–3150 ft (ca. 250–950 m; Site 13) and the nearby area of Puntod at 800 ft (ca. 250 m; Site 14). We obtained a further record of it in Balbagon, Mambajao, at 10 m on 28 May 1992 (Site 1) and in Kital-is, Sagay, at 900–1100 m and 1200–1400 m in May 1994 (Sites 4 and 6, respectively).

Specimens Examined—Total 63. Site 1 (1 FMNH); Site 4 (6 MSU-IIT); Site 6 (5 MSU-IIT); Site 9 (5 DMNH, 4 FMNH); Site 10 (3 DMNH, 4 FMNH); Site 11 (5 DMNH, 11 FMNH); Site 13 (8 DMNH, 3 FMNH); Site 14 (6 DMNH, 2 FMNH).

Dicaeum pygmaeum—Pygmy Flowerpecker

The Pygmy Flowerpecker is common throughout the Philippines, except Mindoro and the Babuyan, Batanes, and Sulu groups of islands, in forest, forest edge, and second growth mainly below 1000 m (Dickinson et al., 1991; Kennedy et al., 2000). A single record exists from Camiguin, taken on 13 June 1968 in Kasangsangan, in the vicinity of Mt. Catarman at an unknown elevation. A specimen of *Columba vitiensis* was obtained on the same date and from the same site at 1000 ft (ca. 300 m).

Specimens Examined—Total 1. Site 11 (1 DMNH).

Family Zosteropidae—White-eyes

Zosterops everetti—Everett's White-eye

Everett's White-eye ranges from the Malay Peninsula, Borneo, and Talaud to the Philippines; it occurs only on the islands southeast of Luzon, from Samar to Mindanao and Cebu to the Sulu and Tawi-tawi groups of islands, in scrub and forest up to 1000 m (Dickinson et al., 1991; Kennedy et al., 2000). Records from Camiguin were obtained from Mt. Catarman and the nearby areas of Gidag-on and Kasangsangan at 500–4950 ft (ca. 150–1500 m) in June 1968 (Sites 9–11). Further records were obtained in June 1969 from Mt. Timpoong at 3150 ft (ca. 950 m; Site 13) and the nearby area of Puntod at 800 ft (ca. 250 m; Site 14).

Specimens Examined—Total 52. Site 9 (4 DMNH, 1 FMNH); Site 10 (11 DMNH, 9 FMNH); Site 11 (4 DMNH, 9 FMNH); Site 13 (4 DMNH, 8 FMNH); Site 14 (2 FMNH).

Zosterops nigrorum—Yellowish White-eye

The Yellowish White-eye is endemic to the Philippines, where it occurs on Luzon, Mindoro, Negros, and Panay and the adjacent small

islands, in forest and forest edge below 1000 m; it is absent from the Babuyan, Mindanao, Palawan, and Sulu groups of islands (Dickinson et al., 1991; Kennedy et al., 2000). The population on Camiguin is the southernmost extension of this species' range and is treated as an endemic subspecies, *Z. n. catarmanensis* (Rand & Rabor, 1969). Records from Camiguin in June 1968 were all obtained from Mt. Catarman at 2000–4950 ft (ca. 600–1500 m; Site 9). Additional records in June 1969 were all obtained from Mt. Timpoong at 3150–5400 ft (ca. 950–1600 m; Sites 12 and 13). We recorded it further on Mt. Mambajao at 1000 m on 29 May 1992 (Site 2) and in Kital-is, Sagay, at 900–1100 m and 1200–1400 m in May 1994 (Sites 4 and 6, respectively).

SPECIMENS EXAMINED—Total 181. Site 2 (2 FMNH); Site 4 (4 MSU-IIT); Site 6 (3 MSU-IIT); Site 9 (53 DMNH, 39 FMNH); Site 12 (36 DMNH, 15 FMNH); Site 13 (20 DMNH, 9 FMNH).

Family Estrildidae—Avadavat, Parrotfinches, and Munias

Lonchura leucogastra—White-Bellied Munia

The White-Bellied Munia ranges from the Malay Peninsula, Sumatra, Borneo, and throughout the Philippines, in forest, forest edge, grassland, and in rice farms (Dickinson et al., 1991; Kennedy et al., 2000). Records of this species on Camiguin were all obtained in Gidagon and Kasangsangan, near Mt. Catarman, at 500–1000 ft (ca. 150–300 m) in June 1968 (Sites 10 and 11).

SPECIMENS EXAMINED—Total 6. Site 10 (1 DMNH, 3 FMNH); Site 11 (1 DMNH, 1 FMNH).

Lonchura malacca—Chestnut Munia

The Chestnut Munia is recorded from India and Nepal to southwestern China, Taiwan, and Southeast Asia and is widespread throughout the Philippines, associated mainly with rice fields, grasslands, and open country. The only records from Camiguin were from Kasangsangan near Mt. Catarman at 1500 ft. (ca. 450 m) on 21–22 June 1968 (Site 11).

SPECIMENS EXAMINED—Total 3. Site 11 (1 DMNH, 2 FMNH).

Sight Records

Following the recommendation appearing in the Rules for New Records (Kennedy et al., 2000), we have deliberately omitted from the Species Accounts all sight records that were not verified or supported by two other observers after the two-year rule for publication. The following is the list of such species, including species identified by calls only, which when verified would constitute additional records for Camiguin and is indicative of the potentially far richer avifauna of Camiguin than the current Species Accounts would suggest. We hope that this listing will encourage other ornithologists and bird-watchers to conduct more studies of Camiguin birds.

Family Accipitridae

Accipiter sp.

Observed by one of us (B.R.T.) along a trail leading to Site 4 on 12 March 1994 between 6 am and 3:30 pm.

Family Columbidae

Ducula poliocephala—Pink-necked Pigeon

Observed by one of us (B.R.T.) along the same trail where an *Accipiter* was sighted (see above), on the same date and time.

Family Cuculidae

Cacomantis merulinus—Plaintive Cuckoo

The call of this cuckoo was noted by B.R.T. at Site 4 on 13 May 1994 as one of the most commonly heard birdcalls at this site. The local name of the bird is *pitokai*.

Family Strigidae

Otus sp.

The call of an unidentified scops-owl was noted by B.R.T. at Site 4 on 14 May 1994 at ca. 5:40 am.

Family Oriolidae

Oriolus sp.

The call of an unidentified oriole was noted by B.R.T. at Site 4 on the same date and time that the scops-owl was heard (see above).

Family Pachycephalidae

Pachycephala sp.

The call of an unidentified whistler was noted by B.R.T. at Site 4 on the same date and time that the scops-owl was heard (see above).

Discussion

The bird fauna of Camiguin is currently represented by 57 species, consisting of 55

resident breeders and two migrants in 26 bird families. Seven species are reported here for the first time: *Ixobrychus cinnamomeus, Porzana fusca, Rallina eurizonoides, Zoothera andromedae, Zoothera dauma, Ficedula hyperythra*, and *Anthus hodgsoni.* Doves and pigeons (Columbidae) are the most diverse family on Camiguin, with eight species recorded on the island, followed by flycatchers (Musicapidae) with six species, and thrushes (Turdidae) with four species. The remaining 22 bird families are represented by one to three species only. Because Camiguin is a volcanic island of recent geological origin and is separated from mainland Mindanao by a sea channel that is only 10 km wide but 385 m deep, it would have not been connected to Mindanao during the many periods of low sea level in the Pleistocene (Heaney, 1986; Heaney & Tabaranza, 2006a). Thus, the current species assemblage reached Camiguin Island by colonization, and their presence on Camiguin is documentation of the capacity of these species for overwater dispersal.

A brief comparison of the birds on Camiguin with those on the closest islands, and sources of potential colonizers, including Mindanao and the central Philippine islands of Negros, Panay, and Cebu, is revealing. Except for the endemic Camiguin Colasisi, or Hanging-Parrot, *Loriculus camiguinensis*, 53 of the remaining species of resident birds are also found on Mindanao; *Zosterops nigrorum* does not occur on Mindanao. With Negros, Panay, and Cebu, Camiguin shares 50, 47, and 42 of its resident bird species, respectively (Dickinson et al., 1991; Kennedy et al., 2000). Luzon, which is farthest away from Camiguin in terms of potential source of colonizers, also shares with it at least 50 resident bird species (Dickinson et al., 1991; Kennedy et al., 2000). These data indicate a remarkably high faunal similarity with Mindanao, though it does not provide clear evidence of biogeographic affinity, given an equally high degree of similarity with Luzon and Panay, for instance. Thus, it appears that Camiguin has been colonized by widespread species.

The presence of at least one species endemic to Camiguin (*Loriculus camiguinensis*, described in this volume) and four endemic subspecies of birds clearly indicates that colonization rates have been so low, even with its proximity to Mindanao, that substantial genetic differentiation has occurred. In this regard, it is noteworthy that none of the other islands adjacent to Mindanao, such as Basilan, Bohol, Dinagat, Leyte, Samar, or Siargao, regardless of area and distance from it, has a single-island endemic (Dickinson et al., 1991; Kennedy et al., 2000; Peterson et al., 2000). All these islands formed part of the Pleistocene island of Greater Mindanao and thus were repeatedly connected by dryland areas during much of the Pleistocene (Heaney, 1986, 2000; Heaney & Regalado, 1998; Steppan et al., 2003), unlike Camiguin, which remained isolated (Heaney & Tabaranza, 2006a).

The current listing of birds on Camiguin is far from comprehensive, pending more systematic field surveys, but based on the quite extensive collection effort during the late 1960s, it is worthwhile to note here the apparent absence or depauperateness of several families that are otherwise well represented on other oceanic islands in the Philippines such as Sibuyan (currently, the most comprehensively studied small oceanic island in the Philippines for birds; see Goodman et al., 1995). Sibuyan also provides a good contrast with Camiguin in terms of the number of species that have successfully colonized oceanic islands in the Philippines. Goodman et al. (1995) identified at least 102 resident species on Sibuyan; Camiguin's current list pales in comparison. Among raptors, for instance, only one eagle, *S. cheela* (Accipitridae), and one owl, *N. philippensis* (Strigidae), have been recorded on Camiguin. Sibuyan, in contrast, has at least six species of eagles, three species of owls, and one species of falcon (Falconidae) present. A similar trend is apparent in rails (Rallidae), swiftlets (Apodidae), and kingfishers (Alcedinidae). Also noteworthy is the poor representation of the larger doves (Columbidae) on Camiguin that occur on Sibuyan, such as *Ducula poliocephala, D. carola, D. aena*, and larger parrots (Psittacidae), such as *Prioniturus discurus* and *Tanygnathus lucionensis* (Goodman et al., 1995).

On the other hand, Camiguin and Sibuyan appear to share the absence of species that are generally associated with wetlands and freshwater swamps (Anhingidae, Threskiornithidae, and Jacanidae) as well as species in high-elevation forest habitats, such as *Orthotomus cucullatus, Bradypterus caudatus, Rhynomyias goodfellowi, Eumyias panayensis, Ficedula crypta, Culicicapa helianthea, Serinus estherae*, and *Pyrrhula leucogenis*, which occur on some of the larger islands, including Mindanao (Dickinson et al., 1991; Goodman et al., 1995; Kennedy et al., 2000).

Both islands also lack some general forest and forest-edge resident birds in the following families: Podargidae, Trogonidae, Capitonidae, Chloropseidae, Paridae, and Sittidae and Laniidae, Dicruridae, Oriolidae, Rhabdornithidae, and Timaliidae. Camiguin also currently lacks records of Turnicidae, Rostratulidae, Scolopacidae, Tytonidae, Caprimulgidae, Hemiprocnidae, Picidae, Eurylaimidae, Hirundinidae, Alaudidae, Oriolidae, and Pachycephalidae.

It is further interesting to note that on Camiguin, in contrast to Sibuyan (Goodman & Gonzales, 1990; Goodman et al., 1995) and other larger and more speciose islands, several widespread species associated with open country, cultivated areas, and disturbed habitats in the lowlands, such as *Pycnonotus goiavier, Rhipidura javanica*, and *Nectarinia jugularis*, are commonly found in relatively intact montane and mossy forest up to the peaks of Mt. Timpoong. A similar pattern in mammals was earlier observed on Negros, which is a relatively depauperate island in terms of mammal diversity, where several commensal species (*Suncus murinus, Rattus exulans*, and *R. tanezumi*) are present and often abundant at all elevations and in all habitat types (Heideman et al., 1987; Heaney et al., 1989), and on Camiguin, where *Suncus murinus* is abundant in montane forest (Heaney & Tabaranza, 1997; Heaney et al., 2006). The documentation of the above pattern of distribution along elevational gradients has led to the hypothesis that the number of species in the native community of small mammals in mature forest determines the success of non-native small mammals on oceanic islands (Heaney et al., 1999). Might this apply to birds on Camiguin as well? Or might habitat disturbance be an equally important factor contributing to this trend in bird diversity and distribution on Camiguin? Camiguin is a volcanically active island, with recorded eruptions of at least two of its volcanos (Hibok-hibok and Vulcan) within recent times. Mt. Hibok-hibok erupted in 1827, 1862, 1871–1875, 1897, 1902, and 1948–1958 and Vulcan in 1871 and 1874 (http://www.volcano.si.edu/gvp/world/volcano.cfm?vnum=0701-08; http://hannover.park.org/Philippines/pinatubo/page9.html). This suggests that the island has had bouts of habitat disturbance brought about by these eruptions, aside from the ongoing human-induced habitat alteration and fragmentation (Heaney & Tabaranza, 2005a). Further surveys of the avifauna of Camiguin will enable a more comprehensive analysis of the factors that influence diversity and distribution patterns of birds among oceanic islands in the Philippines.

Finally, we note that Camiguin is the home not only to a newly described parrot (*Loriculus camiguinensis*; Tello et al., 2006) and four endemic races of birds (*Ixos everetti catarmanensis, Hypothymis azurea catarmanensis, Diceum trigonostigma isidroi*, and *Zosterops nigrorum catarmanensis*) but also to at least two species of mammals (Heaney & Tabaranza, 2006b), one amphibian, and seven plants (Heaney et al., 2006). It clearly warrants protection as a unique portion of the natural heritage of the Philippines. We strongly recommend active protection of the remaining forest. This will benefit the wildlife of the island but will also be essential to the economic and social stability of Camiguin because the mountain forests are the source of the island's essential and precious water. This and other conservation issues are discussed in more detail in Heaney and Tabaranza (2006a).

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